VELOX

ERGONOMIC. ADAPTIVE. PERFORMANCE.

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Team USA Tokyo 2021 Paralympic Uniforms, Weatherproof Training Apparel, and Push Gloves for Women's Push Rim Wheelchair Racers

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Abstract

Paralympic athletes have long been marginalized and fought to have their athletic pursuits recognized as equal to traditional sport. These groups have consistently been left out of marketing and advertising images, as these tend to focus on the cultural body ideal and since advertising influences what the cultural perception of "normal" is, their exclusion perpetuates societal discrimination (Hardin, 2003). An apparel market that has long excluded the needs of disabled individuals has a similar effect. Society is tied to the idea that disabled individuals are associated with tragedy, and that makes people uncomfortable–a reason they've been excluded from advertising, marketing, and having products generally available that cater to their needs. Sports marketing is particularly guilty of this, as evidenced by an ad for the Nike Dri-Goat trail shoe. It reads:

> *"Right about now you're probably asking yourself, "How can a trail running shoe with an outer sole designed like a goat's hoof help me avoid compressing my spinal cord into a Slinky on the side of some unsuspecting conifer, thereby rendering me a drooling, misshapen, non-extreme-trail-running husk of my former self, forced to roam the earth in a motorized wheelchair with my name embossed on one of those cute little license plates you get at carnivals or state fairs, fastened to the back?"* (Lauredhel, 2010)

This is just one example of such transgressions against disabled athletes. However, as Kaitlyn Large puts eloquently in her piece *Why We Need Disabled Athletes in Mainstream Sports*: "The sympathy seems to stem from a misunderstanding about what causes the difference in quality of life for disabled people versus their able-bodied counterparts. Physical impairments are not themselves to blame, but rather a society that does not accommodate difference." By catering to the unique needs of those with disabilities, we can fight this stigma and place para sporting events as equal to Olympic counterparts. Olympic athletes have long been characterized by unique body proportions that aid their sport. Looking at Michael Phelps's long torso or Usain Bolt's long legs, companies have been inspired to create uniforms for these elite athletes. Paralympians don't receive the same treatment and are wearing uniforms designed for traditional athletics, neglecting the fact that their unique bodies and the sports they compete in have different requirements.

The research implications in developing apparel for the needs of wheelchair athletes can be used to benefit the general disabled population as well, which could help with promoting active lifestyles in the disabled community. Participating in sports fosters increased self-esteem, leadership abilities, teamwork, and feelings of inclusion. Fostering a love of sport can be a means for improving quality of life and decreasing the risks associated with a tendency towards inactivity seen in the disabled population (Pamela E. Wilson, 2016). Surveys have also found that youth who've participated in Disabled Sports USA events and programs are twice as likely to be employed as the general population of disabled adults and were more than twice as likely to be physically active throughout life (Survey finds Disabled Sports USA participants twice as likely to be employed as adults with disabilities., 2009). Disabled individuals who participated in recreational sports ranked their general health and quality of life higher than their non-sporting peers (Survey finds Disabled Sports USA participants twice as likely to be employed as adults with disabilities., 2009).

In order to create a more inclusive sport environment, I've chosen to focus my Sports Product Design M.S. capstone project on creating Paralympic uniforms, training apparel, and push gloves for the Tokyo 2021 Women's push rim wheelchair racers.

Part 1: Initial Sport Research

History

Adaptive sports began as a way to rehabilitate WW2 veterans. Dr. Ludwig Guttman was a neurosurgeon and director of a spinal cord injury program at the Stoke Mandeville Hospital; he promoted the use of sports and physical activity as part of the recovery process from spinal cord injuries. In 1948, he hosted the first Stoke Mandeville games in where disabled British veterans with spinal cord injuries could compete in athletics (Pamela E. Wilson, 2016). In 1952 the games developed an international standing with teams coming from The Netherlands, Germany, Sweden and Norway. It was this year that the International Stoke Mandeville Games Federation (ISMGF) was formed as the governing body of the event. The federation developed ties with the IOC to expand the scope of wheelchair sports. In 1960 the games were held in Rome in conjunction with the Olympics. In 1964 the term Paralympics was coined and the event was held every subsequent 4 years (Cooper, 1990). From the beginning track and field was the most popular sport classification with 31 athletes competing from 10 different countries (US Paralympics: Track and Field, n.d.)

Figure 1 Early Wheelchair Racing

The 1964 Tokyo games saw the 200m, 400m, 800m and 1500m races held on the track. Canadian wheelchair racer Chantal Petitclerc took full advantage of the varying race distances to become one of the most decorated Paralympic athletes in history, winning bronze medals in the 200m and 800m distances in 1992 and going on to win two gold medals in 1996. In all she garnered 21 Paralympic medals throughout her career. After her retirement however, USA's Tatyana McFadden has taken over, dominating all distances including the marathon (which was added to the Paralympic program in 1984). As far as major wheelchair marathons go, the Boston Marathon was the first marathon major to host a competitive wheelchair field in 1975. Mcfadden was the first athlete to claim all four wheelchair marathon major titles in a single

year (Boston, London, Chicago, and New York) in 2013 (History of Athletics, 2016). She has since had 4 "grand slams" (winning all four titles) and is the most decorated female wheelchair racer in the world. The current world record for the women's wheelchair marathon in the T54 category is held by Susannah Scaroni in a time of 1:30:44, set at the Grandma's Marathon in Duluth in 2019.

1984 was also the first year the Adaptive Sports Junior Nationals athletics meet was held. It is the oldest and largest continuously held sports event for athletes with physical disabilities ages 6 to 22 in North America. (About Junior Nationals, n.d.). This meet serves as a training ground for many future Paralympic athletes and is where sensations like Tanya McFadden got their start. Before 1984, youth wheelchair races had to compete against their adult counterparts which put them at a disadvantage. Tatyana McFadden has been vocal about rights for athletes with disabilities. Throughout high school, she couldn't compete alongside able-bodied counterparts, so most of her racing was done alone. In 2005 she filed a suit against the Howard County Public School System and won the right for her to race against her classmates. This led to the Maryland Fitness and Athletics Equity for Students with Disabilities Act, which allowed disabled athletes to compete in interscholastic athletics. In 2013, it became federal law so that disabled student athletes across the US could compete in interscholastic athletics (About Tatyana, n.d.).

Sport Playing Field/Environment

Generally speaking, wheelchair athletes will compete in the same arenas as their ambulatory peers. Wheelchair racers will race on the same courses as their counterparts (except in the cases of cross-country races). This means wheelchair races are held on traditional 400m outdoor running tracks, and on road racing courses. On the roads, wheelchair racers will typically have a start some minutes before the running field begins, though obviously at the Paralympic level it is it's own premier event. Wheelchair racing is sanctioned internationally by the international Paralympic Committee and nationally by USA Track and Field and USA Paralympic Track and Field. Distances range from 100m to the marathon, though at specific track meets race distances will vary, and not every disability classification will compete in every

distance at a given race. Common distances for road races include 5 km, 10km, 15km, half-marathon, and marathon (Mitchell, n.d.). Conditions For races will vary with seasonal weather and specific road racing courses, with athletes being able to manage conditions similarly to their non-wheelchair using peers. One thing that can be particularly troublesome to racers though is any type of rain or precipitation. Slippery conditions can make racing dangerous, both with wheels on pavement and with hands on the push rims. In 2019, wet conditions at the Boston Marathon caused Tatyana McFadden to flip her wheelchair early on in the race (Bird, 2019). According to the Road Runners Club of America "Guidelines to Facilitate Participation by Athletes with Disabilities" it is advised that courses avoid severe changes in elevation, abrupt turns (especially at the bottom of hills), and any unfavorable terrain including grass, narrow trails, and uneven pavement.

The Tokyo 2020 Olympics is the first time in recent history that the Paralympic wheelchair marathon course will not follow the same route as the Olympic marathon. Pictured in figure 2, It will start and finish at the Olympic Stadium in Tokyo and wind though the capital going by lots of cultural landmarks (Tokyo 2020 Paralympic Marathon Course Confirmed, 2019). The finish of the race will be on an uphill. The roads are primarily clean asphalt, wheelchair friendly. The Paralympics run from August 25th through September 6th, with the T54 women's push rim wheelchair marathon falling on the final day. Already there has been talk of the potential for extreme heat in Tokyo. The marathon races were moved to start 30 minutes earlier at 6:30 AM in order to better accommodate rising temperatures. August is the peak of Tokyo's summer, with temperatures that can reach as high as 95ºF. September is slightly milder, with average high temperatures of 78ºF. August and September are also particularly

Figure 2 Tokyo 2020 Paralympic wheelchair marathon course

humid, adding to the feeling of oppressive heat. 73-75% humidity is common for that time of year (Monthly weather forecast and climate Tokyo, Japan, n.d.).

Compared to a traditional wheelchair, the push rim racing wheelchair is unique (figure 3). At the elite level, chairs are individually fit to the exact specifications of each athlete. They are incredibly light, ranging from 13 to 22 lbs. The chair is made up of three components, the cage, the wheels, and the steering bar. The cage is where the athlete sits. It has a sling inside where the athlete sits down. The width of the cage is typically adjusted to the hip and shoulder width of the athlete. The racing chair has three wheels: 2 larger wheels mounted in the back to either side of the seat and one smaller wheel in the front. The back wheels are cambered up to 15º to allow the athlete to sit lower in the cage and more easily reach the push rim for the full cycle. It also makes the chair more stable going around turns. In races, athletes will outfit their chairs with carbon fiber wheels to make the chairs lighter and more aerodynamic.

The back wheels are fitted with the push rims that the athlete uses to propel the chair. The steering component is used to turn the chair around curves of the track and cornering on the roads. It's individualized to each athlete based on dominant arm and is set using a spring mechanism because athletes aren't able to steer and push at the same time. There is also a brake included with the steering component (O'Riordan, n.d.). For athletes who compete in the kneeling position, there is a "foot pod" underneath the seat of the chair to hold up the feet from dragging on the track and make the athlete more aerodynamic. There are many rules governing the body of the wheelchair at the Paralympic level. The rules via the World Para Athletics rule book are as follows:

Figure 3 Example of a push rim racing wheelchair

- Wheelchair shall have two large rear wheels and one small front wheel
- All wheelchairs must have a functional braking system
- No mechanical gears or levers are allowed for the purposes of propelling the chair
- The use of mirrors is not permitted

- Athlete must be able to turn the front wheel manually left and right for steering purposes
- Use of fairings or similar devices for aerodynamic purposes is not permitted
- No part of the wheelchair or attachments may incorporate energy storing capacity for the purpose of enhancing performance
- No part of the frame of the wheelchair, or any attachments to it, shall extend forward beyond the hub of the front wheel nor backwards beyond the rearmost vertical plane of the rear wheels. Additionally, the width of the frame, and any of its attachments, shall not be wider than the length between the insides of the rear wheel
- The maximum height from the ground to the bottom of the wheelchair frame shall be 50 cm
- The frame structure must be made of a material which provides sufficient stability and stiffness for safety purposes.
- For the purpose of seat positioning, the frame structure shall incorporate a seat
- The use of Sideguards may be added to protect the athlete from the wheels
- The maximum diameter of the large wheel shall not exceed 70 cm.
- The maximum diameter of the small wheel shall not exceed 50 cm
- Only one plain, round, push-rim is allowed for each large wheel

<u>Sport Rules and Success</u>

The goal of wheelchair racing, like any racing, is to cover the race distance faster than one's competitors. When starting the race, the center of the front axle may not extend over the starting line. The finish of the race occurs when the center of the front axle crosses the finish line. Within the race, competitors must have full clearance of another athlete's front wheel in order to pass, or else be disqualified for interfering with another's race.

Figure 4: Example of racing gloves and helmet used by athletes

As far as safety equipment, athletes are required to wear helmets with a hard, protective shell that is recognized by an international safety standard per the World Para Athletics handbook. Most athletes will wear bike helmets that comply with these rulings. While it isn't explicitly required, most racers will wear gloves that protect the hands from the push rims and allow a more forceful push. Racers are allowed to be barefoot or wear shoes on one or both feet, however these shoes cannot aid the racer in any way or provide a performance advantage. Racers also cannot have their feet touching the ground at any point during the race.

Per World Para Athletics rules, athletes must wear clothing that is clean and non-objectionable. The fabric cannot become transparent when wet and the singlets must be the same color on the front and back of the garment (World Para Athletics Rules and Regulations 2018-2019, 2018-2019). It also notes that athletes should wear clothing approved by their national governing body. There is also an entire handbook put out by the International Paralympic Committee regarding manufacturer identification guidelines for the Tokyo 2020 Paralympic games. The rules listed are as follows:

- No logo may be used in a conspicuous way for advertising purposes
- No unauthorized identification may appear on items
- Only sports brands and clothing brands may appear as identification of manufacture
- Headgear may have one identification of manufacturer up to $10cm^2$ in size
- Armbands may have one logo up to $6cm^2$ in size
- The size of identification of manufacturer on clothing shouldn't exceed $30cm^2$ in size
- One logo is permitted on zippers and buttons, but should appear in the same color as the concerned item
- For sports equipment provided by the athlete or NPC, the size and frequency of logo should be congruent with product sold at retail in the 6 months prior to the games. Equipment is subject to individual IF rules
- All footwear items can have 1 logo per item and sizes should be congruent with product sold at retail in the 6 months prior to the games
- No authorized identification (logos or country names) should appear on the neck, collar, or on the body (i.e. tattoos)

- On upper body clothing, the identification of manufacturer should be placed on the chest or on the sleeve
- Identifications of manufacturer may not appear close or adjacent to one another, in order to avoid a composite logo effect
- No third-party references are allowed (i.e. social media hashtags and accounts, corporate design or color scheme, URL, National Federations, International Federations, public or governmental authorities, and clubs with the exception of international federations identifications as authorized by the IPC)
- Designs may only be used for one summer and winter Paralympic games, but must be changed by the following summer or winter Paralympic games
- Drawings, color schemes, combinations, patterns, prints, letters, numerals, geometric elements, slogans, taglines, words, or designs that refer to or create the impression that they are similar to the manufacturers logo may not be used in the designs of items for the Paralympic games
- Countries are encouraged to use national colors, names, flags, and emblems, as well as national identification emblems in order to visually enhance the national identity of items
- No maximum frequency or sizes are applied to national identifications
- No item may feature lyrics from national anthems, motivational words, public or political messaging, or slogans related to national identity
- Uniforms may not include any Olympic marks, international sport federation emblems, IPC marks, or any form of propaganda
- NPC may use the Tokyo 2020 logos so long as they are the approved wordmarks, are not being used for commercial purposes (for replica merchandise), and may ony be used once per item of clothing (up to $30cm^2$)
- It is forbidden to use the Tokyo 2020 wordmark in association with the identification of manufacturer

- When the Tokyo 2020 wordmark is used in conjunction with the National emblem or IF identification, the Tokyo 2020 wordmark should be placed below the national emblem, separated by a gap or dividing line
- Where clothing contains elastic material, identification of manufacturer will be measured stretched

(IPC Manufacturer Identification Guidelines: Tokyo 2020 Paralympic Games General Guidelines, 2020)

Per USATF guidelines, athletes are just required to wear exclusively Team USA issued uniforms (Athlete uniform Guidelines 2019, 2019).

Athlete, Consumer, User Data

Via the World Para Athletics Association, athletes are put into classifications based on disability type. The goal is to put athletes into categories in which impairments cause similar levels of limitation to athletic activity. To be eligible for para athletics, an athlete must have an impairment deemed severe enough to have an impact on athletic performance. In wheelchair racing, there are 7 classes, with class T54 reflecting the highest amount of muscular function in the wheelchair racing events. Athletes in the T54 classification have full muscle power in the arms and some to full muscle power in the trunk. They may have some function in the legs as well. Disabilities that lead to this classification are typically spinal cord injuries or lower limb loss.

The 2019 Chicago marathon served as the trials race for the 2020 Paralympics, and on the women's side Tatyana McFadden and Susannah Scaroni earned spots to represent the United States. Tatyana Mcfadden was born with spina bifida, and has had limited use of her legs since birth. She was adopted from a Russian orphanage when she was 6 and told by doctors she probably wouldn't live long due to her condition. She tried many sports at a young age in an effort to build her strength and fell in love with track and field. When she was 15, she made her Paralympic debut in Athens winning 2 medals. At the world championships following, she went on to set a world record in the 100m event. She returned to the Paralympics in Beijing and London. By the end of 2016 she had world records in the 100m, 400m, 800m, 1500m, and

5k. She began racing marathons in 2009 and between 2013 and 2016 she won 4 "grand slams" were she won all 4 world majors wheelchair marathons. In 2013 she participated in the winter Paralympics in Sochi Russia in the cross-country ski event where she won silver. She is an advocate for athletes with disabilities (About Tatyana, n.d.). Susannah Scarnoi suffered a spinal cord injury when she was 5 years old that left her paralyzed from the waist down. She has been in the Paralympics twice in 2012 and 2016. In 2016 she was 7th in the marathon. She is a native of Washington and trains in Illinois at University of Illinois Urbana-Champaign where she also studies nutritional science. Last June she set the Paralympic wheelchair marathon world record 1:30:42 at the Grandma's Marathon in Duluth, MN (Telegram, 2019).

Pertinent market size and potential

The market for Paralympic uniforms for women's wheelchair marathon racers is small, as the fields for wheelchair marathons are typically not large. As an example, the 2019 Chicago wheelchair marathon featured 27 para athletes (men and women combined), which is considered a huge field (Tennery, 2019). In 2019, there were 5 women in the T54 category named to the Para world championship marathon team, which is another avenue to use the technology from the Paralympic uniforms (Zhang, 2019). However, design implications will reach further than just these elite athletes. Typically, the technology and learnings from creating product for elite athletes can trickle down into consumer product. There is almost nothing in the market for sports apparel addressing the needs of adapted sports and individuals in wheelchairs, which is disheartening considering how beneficial living an active lifestyle is to those in a wheelchair. In 2002 there were approximately 2.8 million wheelchair users in the U.S and it's estimated that approximately 4,000 to 5,000 physically disabled individuals are involved in athletic competition within the United States with an even larger number participating in recreational sports.

Athlete Experience needed to accomplish activity

Learning proper technique for racing can be quite difficult, as body positioning is very different than being in a traditional wheelchair. The athlete sits much closer to the ground in

the racing wheelchair with the weight leaned forward so the shoulder drops much closer to the ground. This helps put enough weight onto the front wheel to keep the wheelchair moving in a straight line. When the athlete wishes to turn however, they must lean back so that they can set the turning mechanism. Finding the proper balance of getting the front tire to skip off the ground without tipping the wheelchair backward takes practice. While in a traditional wheelchair the user grasps the push rim and pulls the wheel around the cycle, in a racing wheelchair it is most efficient not to grasp the wheel at all. Instead the user just pushes the handle; getting the proper hand angle takes finessing. The positioning of the body can also put stress on breathing since the user isn't sitting upright and instead can put the lungs into a somewhat collapsed position (LIzzie, 2015).

The training to be one of the best wheelchair racers in the world is incredibly demanding. In her build up to the Tokyo Paralympics, Tatyana McFadden says her workouts include approximately 120 mile a week in her racing chair and lifts weights twice a week. She also plans to race (Dolan, 2018). Susannah Sarconi's training consists of three days of road workouts and three days of track training each week with sessions amounting to approximately 90 minutes. On the road she will do steady pushes of 75%-80% intensity, with the track session being shorter race pace mile repeats workouts (Susannah Scaroni, n.d.). Push rim wheelchair racing heavily taxes muscle groups of the upper body, including the anterior deltoids, pecs, triceps, forearms, and lats. Strength training for these muscle groups is important to maximize power output for short stretches of time as well as allowing a greater capacity for longer races. Strengthening the antagonist muscle groups is important as well for minimizing injury risk.

Physiological and Biomechanical needs of athlete

In general, when the athlete is in the wheelchair, they are in hip flexion and thoracic and lumbar flexion. To maximize power output with each stroke, athletes extend the shoulder

Figure 5 Racing wheelchair positioning pictured from left: sitting, kneeling, kneeling with feet down

so the elbows draw back behind the ribcage, swing forward with an upward rotation of the scapulae, then drive downward with a forceful tricep extension (Biomechanics of Push Rim Wheelchair Racing, n.d.).

There are two different positions that an athlete can take in a push rim wheelchair. There is the kneeling stance and the sitting stance, pictured in figure 5 (the third stance is the same as the kneeling stance but for athletes who may require a foot bar because of certain disabilities). The kneeling stance is the favored body position, since it is more aerodynamic. It also puts the athlete in a more powerful pushing position. In this position, the legs are tucked up underneath the body and the torso is at a nearly horizontal position However, it requires full upper body strength and minimal spasming to move the torso up and down with the pushing of the rim. The sitting stance is favored by athletes who may experience breathing difficulty or excessive spasticity in the kneeling position. It's typically used by athletes with less upper body function, or amputees who may choose it if it's more comfortable.

The propulsion cycles of each push of the push rim is made up of 6 phases. First, the athlete pulls arms and hands upward and as far behind the wheel as flexibility will allow (phase A in the diagram). They accelerate hands downward towards the push rim until it hits at point B which is the point of kinetic energy transfer from hand to wheel. During phase C, force is applied to the push rim to move it around the rotation, with most of this force coming from the shoulders and elbows. At the bottom of the push rim, the athlete will pronate the hand inward or outward as they take them off the rim to give a last flick of the handle on the wheel with either the thumb or index and middle finger respectively. This then leads to the cast-off phase where the hands leave the rims. The

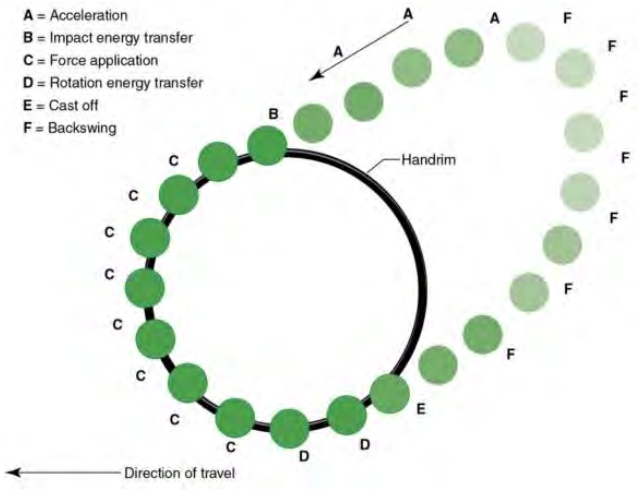


Figure 6 Push rim wheelchair racing push cycle

athlete then must quickly bring hands back to the starting position during the backswing phase to prepare for the next stroke.

Changes in terrain can affect the length and force applied of these cycles. During uphill racing portions athletes will shorten the acceleration as to minimize time in which hands aren't on the rims so that the chair can't roll backwards. If an athlete is accelerating, they will increase the number of strokes and increase their backswing.

There are also slight variations amongst tactics used for track racing versus road racing. While general technique is very similar, the logistics of racing on a closed track and an open road are different. According to University of Illinois wheelchair track and road racing team "On the track, reaction time and chair control are in far greater demand than on the road" and "being able to burrow into a tight gliding position on descents is a needed skill for the road, but of little use on the track." (Wheelchair Racing, n.d.).

In a study on injuries incurred by wheelchair athletes, it was found that 72% of the study participants reported at least one injury from the time of their initial participation in wheelchair sports. The most common injuries reported were soft tissue injuries, blisters, and skin lacerations. Soft tissue injuries were most commonly seen in shoulders, elbows, wrists, and hands. Of all the sports in the study, track had the highest incident of injury (also had the highest amount of participants of all the sports surveyed, and road racing was third. Overuse injuries of soft tissue are the most commonly seen injury in wheelchair track athletes. These injuries include strains of upper extremity muscles and sprains of shoulder ligaments. Like any sport with such repetitive motions, muscle imbalances can show up in wheelchair athletes and this can lead to injury. Shoulder muscle imbalance, with weakness in the humeral head depressors can lead to rotator cuff injuries and rotator cuff impingement syndrome. When the deltoid muscles are used to lift the arm and elbow back behind the body to begin the push rim cycle, it can elevate the humerus into the acromian which can irritate the supraspinatus tendon, the subacromial bursa, or the bicep tendon (Astley, 2012). Blisters of the hands accounted for 20 to 30 percent of all recorded injuries. Lacerations of the hands from the push rims and on the upper arms from the wheels were also prevalent among push rim wheelchair racers (Kathleen A. Curtis, 1985). Hand protection from blisters and laceration and arm

protection from the wheels of the wheelchair are all things to consider in the design of athletic apparel for youth push rim wheelchair racers.

The dissipation of heat for wheelchair athletes is a unique problem that hasn't been heavily studied. It is influenced by a whole host of factors, but two major ones. The first factor is that the seated position limits air flow on the backline of the body and limits the evaporative cooling response accordingly. The second is that athletes with spinal cord injuries, which is a common cause of para sport participation, don't thermoregulate the same way in their lower extremities below the site of the spinal lesion as their upper extremities. Paraplegic athletes have compromised blood flow to lower extremities, so they don't dissipate heat as effectively. Because of this, there is a greater heat storage for a given metabolic rate in individuals with spinal cord injuries (though this effect is more pronounced in tetraplegic individuals as opposed to paraplegic athletes). They also have greater heat storage in the lower extremities and a lower whole body sweat rate (Price, 2012). The predicted temperatures for the Tokyo 2020 Paralympics are going to be extremely hot, so keeping athletes cool will be paramount.

The world record wheelchair marathon time of 1:30:44 is equivalent to ~17.34 miles per hour or 7.75 meters per second. This speed presents a unique low-speed aerodynamic condition (when compared to events like cycling which are performed at much higher speeds). Aerodynamic drag on the wheelchair athlete can come from two forces: surface drag and form drag. The surface drag is caused by the adhesion of air molecule to the surface of the object moving through space. Form drag is caused by the difference in air pressure between the front and back of the object moving through space. Aerodynamic drag represents about 40% of the force acting to slow down a wheelchair racer, so solutions that minimize drag can have a significant impact on the race (Joseph Winnick, n.d.) In a study looking at Paralympic wheelchair racers in the Rio 2016 Paralympics, it was found that the female racers (as compared to the men racing) that medaled were aided more in assuming a better aerodynamic position by minimizing the frontal area in their assumed position, possibly because of their reduced power output. Men racing were more able to overcome less aerodynamic positioning with greater power output (Amy Lewis, 2017).

Clothing that physically caters to the disability of the wheelchair athlete is important, sport performance characteristics aside. Being able to put on and take off clothing independently and providing a physiological and psychological sense of comfort in one's apparel is the goal of adaptive clothing design. Anthropometric characteristics change when a person is seated for long periods of time. The hip bones spread out differently and stomach muscles are used in a different way. Thus, pattern modifications need to be made to adjust for the spreading of fat and muscle at the thighs when seated and at the stomach region as well. Ease of movement is pivotal in all design, but especially the design of sporting garments. When the athlete has to transfer from the daily wheelchair to the racing wheelchair and negotiate leg positioning, garments that stay out of the way are key. Easy access to garment openings and pockets is also important to consider. Most pants pockets placed on the back and front of the pants are useless to wheelchair users in their working position. Easy to manipulate fasteners like Velcro and magnets are important to consider so that individuals can take as much individual control over the donning and doffing of garments as possible as well as making garments easier for caretakers to assist with. Finally, the fit or the garments is different for those using wheelchairs. Things to consider are: higher back rise and lower front rise to mimic body measurements when seated, elasticated waistbands, shaped back waist, and a longer pant length to provide ankle coverage (Suri, 2016). Neckline rise is also important to consider as athletes in push rim racing spend a lot of time with their torso bent forward, causing loose necklines to hang open. This also means workout tops should be longer in the back to avoid pulling up with the athlete leans forward. When considering patterning, avoiding seaming in areas with a lot of movement is important too. Since there is a high amount of movement in the shoulders and arms during a push rim race, creating garments that avoid seams along the inside of the arm and in the armpit is ideal to minimize chafing concerns.

Competitor Product Research

Figure 9 Nike's Rio 2016 Track and Field Uniforms

Currently, the Paralympic uniforms are the same as the Olympic uniforms. In 2016, for the Rio Summer Olympics, Nike debuted innovative new uniforms for the track and field team inspired by a blue feather from a Brazilian bird. The uniforms, titled the Vapor track and field kit, feature rubber 3D printed "aeroblades" strategically placed to make the runners more aerodynamic and reduce drag on their clothing. When an Olympian makes the team, they have a choice of what silhouette of uniform they'd like to compete in from several provided options. While I was unable to find a full breakdown of what these options are, based upon photos it appears that most of the wheelchair racers wore a looser option of singlet (as opposed to the cropped one worn by the Olympic marathon runners traditionally or the cropped tee often seen on sprinters), as well as full length or ¾ length matching leggings (Figure 8). Included in the kits is also a pair of arm and leg sleeves outfitted with the same aeroblades as the uniform. If an athlete chooses not to wear the arm/leg sleeves but still wishes to have some of the aerodynamic advantage, Nike also offers AeroTape, which is applied like KT tape and features the same aeroblades as the kit (Figure 9).

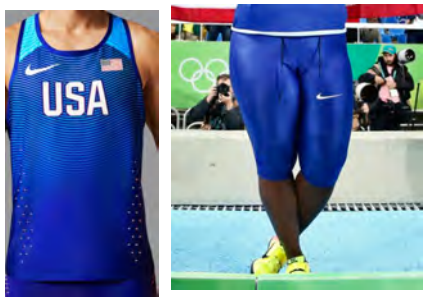


Figure 8 Close up of singlet and leggings likely worn by wheelchair racers

Figure 7 Nike Arm Sleeves, Leg Sleeves, and Tape enhanced with aerodynamic AeroBlades

Athletes are allowed to use their own gloves and helmets for the races. There are two main types of gloves in the market: hard thermoplastic gloves and soft leather. The leather gloves are available commercially and come in a range of sizes. They look a bit like boxing gloves and cushion the hand from some of the impact of the push rim. These are typically recommended for newer athletes to the sport. The most popular brand of soft gloves are from

a brand called Harness which offers different silhouettes and levels of coverage. These range from $190-$220 a pair. They have varying levels of foam padding on different surfaces to accommodate different pushing styles and some feature a lobster silhouette for added dexterity (Racing Gloves, n.d.). The rigid options are made of a thermoplastic material that is molded to the exact specifications of the athlete's hands. These facilitate a more efficient energy transfer for pushing off. The most popular styles are from a brand called Ingenium developed by a wheelchair racer from University of Illinois. These retail for a price of $150 (Shop: The Chief, n.d.), so much cheaper and more breathable than the softer counterpart. Some athletes will opt to create their own gloves with kits sold by manufacturers. Ultimately athletes may choose whatever they are most comfortable with as well as what their disability will allow for (Mitchell, n.d.).

Figure 10 Harness soft leather gloves (top 2) and ingenium Rigid 3D printed gloves (bottom 2)

In the Team USA "swag bag" given to the athletes, there is a number of apparel, footwear, and equipment items given to the team for the purposes of warm up, lounge, training, and wearing around the Olympic village. In the women's bag, the following Nike items are included (pictured in figure 11): two sports bras, three pairs of workout leggings, six T-shirts, four tank tops, two warm up jackets, two long sleeve pullovers, two hats, two pairs of athletic shoes, one pair of sandals, three pairs of socks, four pairs of shorts, a water bottle, a wrist strap, a passport cover, a watch, a drawstring bag, and a branded duffle bag. However, the team USA apparel is not adapted to the needs of wheelchair users, and is instead catered to the needs of runners or other athletes in an upright and standing position. The weatherproof jacket allotted

Figure 11 Nike Team USA Issued swag

Figure 12 Team USA Weatherproof Jacket

in their kit is a traditional Nike storm fit jacket equipped with a breathable waterproof membrane on a polyester shell. It has seam sealed seams, a high collar with velcro adjustable cuffs, and a removeable hood via a zip. There is a heat press "USA" graphic along the front of the garment (figure 12). The leggings given to athletes as a part of the kit are traditional cut & sew polyester garments made of a 4 way stretch fabric. They are typically crafted using a flat seam construction. While specific styles couldn't be found for what they'd received, pictures can be seen in figure 11. Sometimes garments will feauture laser cut hemlines but this is typically only on higher pricepoint items.

Anatomy of State of the Art Product

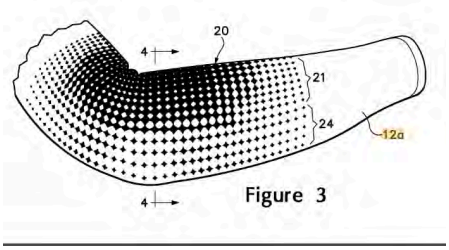
Figure 13 Closeup of Nike's Aeroblades

Typically clothing is crafted through a cut and sew method of knit and woven fabrics. Where some of the problems lie is that patterns are crafted based off the body in a standing position, when Paralympians in wheelchairs compete in a seated position. This means that there is excess fabric in certain areas and that the fabric is stretched and lengths shortened in others. The Nike track kit feature edges to minimize weight and prevent chafing along the neckline and armholes of the garment. The patterning is minimal to keep the garment streamlined and lightweight. The fabric is recycled polyester knit which is printed with sublimation to imbue the uniform with the national colors. The graphics and logos are heat pressed to the garments. The more fitted garments will feature a mixture of recycled polyester and spandex so they can stretch to fit the body. The aeroblades are a recycled polyester compound adhered to the garment in areas that will affect the turbulent airflow around the body as an athlete moves and reduces drag (Nike Vapor Track & Field Kits with AeroSwift Technology, 2016). Typically garments engineered for aerodynamics will use serged seams as to reduce potential for drag caused by the texture of flat lock stitching. Fitted garments can use either, as flat lock seams tend to be more comfortable close to the body.

The gloves commonly seen by on the elite level wheelchair racers are either the gloves by Ingenium or a similar model. These gloves utilize 3D printing to cheapen manufacturing costs. The glove is 3D printed with a rigid plastic filament and features an internal honeycomb structure to make it lightweight while still keeping it very strong. The creation of the gloves is still very small scale, since the market isn't very large. It relies on athletes taking measurements of their thumb width and the width of their index and middle finger in order to determine sizing. It has an elastic strap that stretches around the back of the hand to keep the glove in place and a rubber surface on the palmar surface to pad the hand, as well as rubber on the pushing surface in order to better grip the push rim. The do-it-yourself kits generally include thermoplastic sheets that can be softened in hot water, then formed around an athlete's hand in order to personalize fit, though the rest of the glove must then be constructed by the athlete (attachment of rubber and elastic straps). The soft gloves use a semi-rigid leather outer with a foam interior for padding and rubber at the points that contact the chair to allow for better grip. In the Harness models there is a rib knit textile cuff and a Velcro closure that promotes proper hand positioning.

The warm up and weatherproof apparel featured in the Team USA issued gear is all slightly different but has some general similar components. Everything is some blend of polyester, spandex, and cotton fibers (because the apparel is no longer available for retail, specific makeup is difficult to find). The comfort items like the tees will feature a jersey knit and are typically a fabric blend that is cotton plaited with polyester on the interior, so it has the hand feel of cotton with the moisture wicking benefits of polyester. The fitted training pieces like the leggings, sports bras, and tanks will be polyester blended with spandex and are generally a knit cut & sew construction, though they can also feature a seamless knit construction to minimize seams and potential for irritation. Based on the photo presented, it also appears that athletes may have received AeroAdapt tees, which was a Nike fabric technology and knit structure that allowed for adaptable air flow based on how much the athlete was sweating. The jackets will feature a woven fabric that is probably a blend of a synthetic fiber like nylon or polyester with some kind of water repellant finish or potentially a Gore-Tex film to allow the jacket to remain breathable.

Utility Patent Landscape



US860163B2: Article of Apparel with Zonal Stretch Resistance
Filed by Nike Inc
Pattern knitted into or printed onto a cylindrical portion of textile that has a different density than textile and allows for muscle support preventing overuse injuries.
(USA Patent No. US8601613B2, 2005).

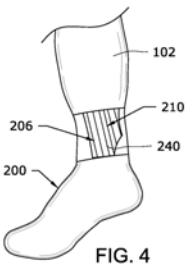


FIG. 4

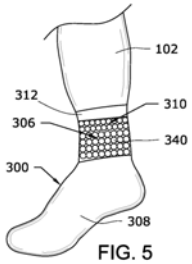
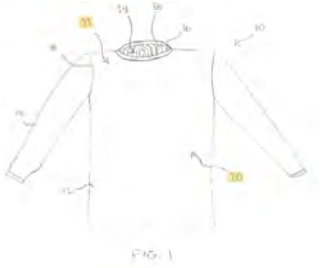
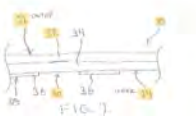


FIG. 5

US 8745769: Apparel with Reduced Drag Coefficient
Filed by Nike inc
An athletic garment including a panel designed to reduce frictional and pressure drag around the appendage of an athlete competing in a high speed event such as running and cycling. The panel encircles the appendage and includes texture to texture designed to enhance the laminar boundary layer.
(USA Patent No. 8745769, 2014).





US9719206B2: Apparel with heat retention layer and method of making the same
Filed by Under Armour
A ceramic print on the interior of a garment with the ceramic portion including at least 5% ceramic by weight and covers at least 10% of the garment interior
(USA Patent No. US9719206B2, 2012).

SWOT Analysis

Paralympic Uniform

S	W
-Aerodynamic Innovation -Moisture-wicking properties -Laser cut ventilation -Efforts made to avoid chafing, flat edges -Different silhouettes available (loose singlet, cropped top, leggings vs. shorts) -Blue Uniform stood out amongst other countries	-Not patterned for the working position of a wheelchair athlete -aerodynamic properties not optimized to wheelchair position -Thermoregulatory differences in individuals with paralysis not taken into account -Front of singlet graphics aren't visible when athlete is in action
O	**T**
-Research working position of wheelchair athletes to improve patterning for uniform -apply texture to areas optimal for aerodynamics in wheelchair racing position -research how to cool the body most effectively for individuals with paralysis -Apply graphics in a way that they are visible when the athlete is competing	-Olympic uniform regulations -Competing needs (arm protection from wheels vs. keeping arms exposed for cooling) -Small Target Market

Weatherproof Apparel

S	W
- Aesthetically Pleasing - Quality Construction - Breathable & Waterproof	- Not ergonomically designed for wheelchair racing athletes - Details like hoods and pockets are unuseable to wheelchair racing athletes -Graphics aren't informed by the positioning of wheelchair racing -Weatherproof apparel that interfaces well with the chairs
O	**T**
- Apparel designed to the ergonomic and anthropometric needs of wheelchair racing athletes -Minimal and performance driven apparel fitted to the athletes designed to interface well with their racing chairs -Leggings that provide some weather protective advantage to the athlete via wind and water resistant panelling	- Some cycling apparel begins to address the positioning needs of athletes - Market for wheelchair racing apparel is small

Wheelchair Racing Gloves

S	W
-Market is already centered around individualized fit with DIY thermoplastic kits and 3D printed models -3D printing as a primary manufacturing method is already being used	-Rigid gloves seem uncomfortable and potentially not secure to the hand with singular elastic strap -Potential for blisters since gloves can move on hand and there is no textile liner -Potentially slippery when wet or sweaty -Limited dexterity
O	**T**
-Rigid piece integrated into a textile glove for enhanced fit -Increasing dexterity without sacrificing protection -Better sweat management -More ergonimic design -Better integration of glove with overall uniform	-Unique fit to each athlete -Differentiating from 3D printed gloves in the market -Balancing athlete needs (protection, thermoregulation, dexterity, ease of donning & doffing)

<u>Core Strengths</u>

I believe as a designer, my core strengths lie in my ability to design into multiple product categories, my prototyping ability, my thorough research, and my passion for sports that comes from being an athlete myself. My strengths support this project because I will be designing apparel and equipment for these athletes, showcasing my versatility as a designer. It will require a lot of research into patterning for different body positioning, which will require data collection via body scanning, as well as researching into thermoregulation and aerodynamics and how to utilize that information in the design of a uniform. I'll also be looking into how to support recovery for these athletes. Finally, the research itself feels important to me because it is working to help empower individuals to participate in sports at athletes highest level, which is something I feel I can be fully invested in for the course of the project.

Ultimately I believe I want to be working on performance product innovation for elite athletes in the apparel realm. This project supports this because it is focused on the physiological and biomechanical needs of elite women athletes. It also ties back to my reasons for wanting to get into sports product design in the first place, namely wanting to help all individuals experience the amazing experiences sports have to offer. By focusing on the needs of wheelchair para athletes, the project is broadening the scope of the sports product market to better appeal to athletes of all body types and is making the industry less exclusive to those who fall outside of the norm.

Part 2: Field Research Insights

Research Methods

For this second phase of research in the project, I looked to field research, athlete and expert interviews, and athlete surveys to dial in on the problems athletes are facing with their products. For field research, I reached out to the wheelchair racing team at University of Illinois Champaign-Urbana. They have a successful collegiate team, and many men and women choose to stay there post-collegiately to train for the Paralympics. I was lucky enough to talk with coach Adam Bleakney, as well as Paralympians Susannah Scaroni, Arielle Rausin, and Yen Haong about the sport in general as well as their unique product experiences. I observed practices and interviewed athletes in their training environment, nailing down what they liked and disliked about their competition uniforms, as well as training apparel in general. I also got a deep dive into the history of racing gloves and how manipulations to the gloves can impact biomechanics. The interview questions for each individual are outlined in appendix A, and I used insights from those interviews to compile the following insights on apparel and racing glove concerns. I also took anthropometric measurements of Yen Haong and Susannah Scaroni.

Apparel Concerns:

Anthropometry & Fit

"When we get Team USA gear, it's just generic Nike sizing, but obviously our lower bodies are a lot smaller" was one of the key pieces of insight I learned from my interview with Paralympian Yen Haong. Fit problems garnered most of the attention throughout our conversation, with Yen emphasizing how lucky she was that her mother was a seamstress because her clothing often needed to be altered. She cited that for pants, she often needs to get a larger size, then take things in at the waist and ankles in order to fit her lower body. Tops are the same way, with her sizing up to fit her shoulders and chest, which become overdeveloped with the muscles used in wheelchair racing, then taking in at the torso and waist. These responses were reflected in the athlete survey as well, as many athletes reported having to shorten lengths of items and take in the waist and legs of things. When discussing the fit of racing apparel, athletes lamented the time they were given one-piece speed suits by Team

USA in 2012. Because of the typical size difference between the athletes' upper and lower bodies, the one-piece uniforms didn't fit anyone properly. The anthropometric measurements I took of the athletes confirmed the proportioning difficulties they talked about.

In terms of sport specific fit, the commonly cited concerns regarding clothing were having tight fitting clothing, high necklines and midrise leggings, and silhouettes that allowed for optimal mobility. The racers are fit tightly into their chairs, with added padding and upholstery around the body to fit their unique anatomy. They are strapped into a position that puts them close to the wheels, so silhouettes that are bulky are not only uncomfortable, but dangerous. A preference for tighter fitted tank tops and tight sleeves was unanimous amongst the athletes I talked to, and with sleeved tops, something that was difficult to find because of the anthropometric differences between wheelchair racers and other athletes mentioned above. The shoulder breadth issue was also a reason some athletes chose to purchase men's apparel, since traditional women's sizing typically has much narrower shoulders.

High necklines were also unanimously favored amongst the women I talked to. The working position of the wheelchair racing athlete puts them in an extreme forward leaning position. Because of this, when necklines are too loose and low, it can expose a lot of the chest which can leave female athletes uncomfortable. To combat this, sometimes athletes will layer underneath their tank tops, or they will tie the straps up in the back of the top to raise the neckline. Most athletes said they preferred a neckline almost as high as the collarbone. For similar reasons, mid-rise leggings were favored amongst athletes. With the working position of racing, if the rise of pants are too low, they will pull down as the athlete leans forward. However, if the rise is too high, the waistband can fold over in the front uncomfortably as the athlete leans forward. Even in their daily wheelchairs, the front rise sometimes still comes up too high. Athletes I talked to fixed this by folding waistbands over in the front (figure 18).

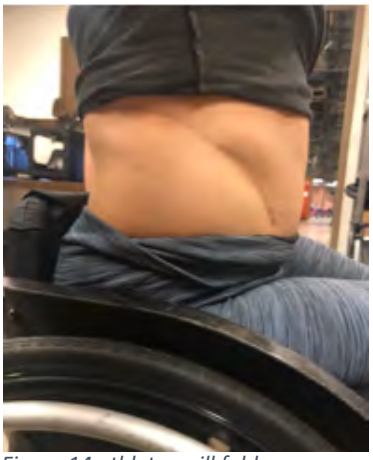


Figure 14 athletes will fold waistbands over for better fit

Finally, mobility in the shoulder region was cited as a big concern when looking for apparel tops. In tank tops, racer back silhouettes are favored because it keeps straps from

slipping off the shoulders and allows the shoulder to move freely. When talking with Paralympic racer Arielle Rausin, she mentioned an instance in which she wore a sports bra with traditional straight straps in a workout and was forced to continually pull them back up onto her shoulders throughout the workout as they kept slipping. Mobility was also a big concern when athletes were looking at sleeved tops and jackets. Weatherproof apparel is extremely hard to find for wheelchair racing athletes because the fabrics are typically woven and non-stretch, and they are designed for running which requires minimal shoulder range of motion. This is worsened when athletes try to layer clothing underneath in cold racing environments. As a result, when athletes have to race in the rain or cold, they will often sacrifice thermoregulatory comfort and weather protection for mobility. Paralympian Susannah Scaroni mentioned that for the Boston Marathon in 2018, she duct taped trash bags beneath her shirt in order to keep the rain from chilling her during the race.

Thermoregulation & Sweat Management

Women typically sweat most in between breasts, at armpits, and on the center upper back, as well as in the interior of the elbow and behind the knee (Lucy Dunne, 2015). To maximize evaporative cooling, athletic clothing is generally designed to incorporate ventilation in the areas of maximum sweating, especially along the backline of the body. When an athlete is in an upright position, this ventilation coupled with moisture wicking textiles on the front of the body allows the athlete to remain comfortable, cool, and dry. In interviews, athletes cited getting sweaty stomachs (figure 19). Because of the working position of the wheelchair racing athlete, it is difficult to allow for evaporative cooling and sweat management on the front of the torso. As a result, athletes often finish workouts with large wet patches on the front of the torso in the stomach region in the area that is pressed up against their legs (this was confirmed in athlete observation). Athletes also cited the quads getting sweaty because of their

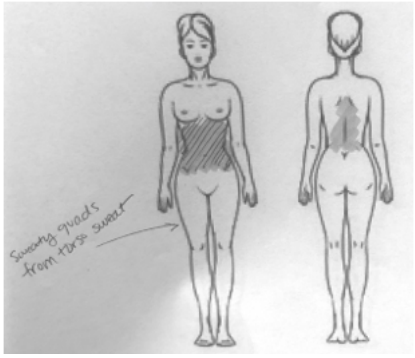


Figure 15 Athletes reported sweaty stomachs and quads in their working position while racing

interaction with the upper body, even though the front upper leg is not an area of the body that produces a lot of sweat on it's own.

Irritation & Chafing

Irritation and chafing are concerning in wheelchair racing and with Paralympic athletes in general. The main areas of irritation cited by athletes were along the inside of the arm. This is due to chafing against the armpit and interaction with the fenders of the wheelchair. In order to minimize chafing concerns in the armpits, athletes said they preferred tank top silhouettes that had minimal edges and an armhole that didn't drop too low. Some athletes prefer to wear tops with sleeves to minimize skin on skin interaction at the armpit. The other concern with inner arm interaction with the wheelchair varies largely based on the positioning of the athlete in the chair and the width of the fenders compared to where the athlete sits. Irritation can occur anywhere from the upper bicep to the interior of the elbow. This irritation can take for as bruising from the athlete's arms hitting the fenders repeatedly, or lacerations from missing a stroke on the push rim. To combat this, athletes will often wear sleeved tops underneath racing uniforms, or wear arm sleeves to protect themselves. Some athletes even went so far as to wear arm padding for protection. The image depicts an athlete utilizing football pads turned inward in order to protect the inner bicep from her chair (figure 20).

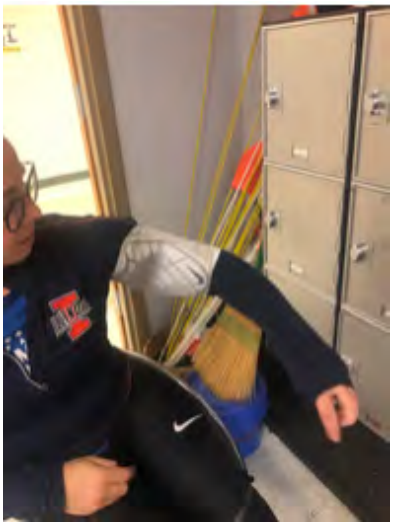


Figure 16 Athlete uses football pads to protect inner arms from chafing on racing chair

Lower body irritation and any irritation below the sensation line is also hugely concerning for athletes, namely because paraplegic athletes are unable to feel the irritation occurring. Blood flow to lower extremities is also limited in paraplegic athletes, so healing of these wounds is slow. All the athletes I talked to preferred leggings over shorts for this reason, to help minimize risk of irritation from the chairs. The majority of athletes even preferred ankle length tights, no matter the weather conditions. Leggings with minimal details were preferred as well, as anything with pockets or extra style lines and seams

has potential to cause chafing against the body. Athletes also disliked racing in cropped style tops, since the straps and upholstery used to secure the athlete into the chair can come across the low back and leaves potential for rubbing and abrasion. This is also another reason that tighter fitting tops and pants are preferred since excess fabric pressed against the body also provides potential for irritation.

Durability & Wear

Since it is common for wheelchair racing athletes to race numerous events ranging from the 100m all the way to the marathon, durability in uniforms is paramount. However, the working position of the athlete puts stress on areas that differ vastly from the running position that their uniforms were crafted for. Susannah Scaroni mentioned in her interview that after the games, many athletes wearing the singlets in practice had the uniform separate and rip at the shoulder seam because of the strain on the garment there. Numerous athletes also stated that they experienced holes in the bum of their leggings, which makes sense because of the strain put on the garment there as well as the friction of the pants fabric against the wheelchair. Athletes hadn't found a good solution to either of these issues and so they just replace garments more often

Other Apparel Details

When discussing the most recent Team USA uniforms with wheelchair athletes who competed in them, one of the first topics to come up were the "Aeroblades" and their inability to interface with the athletes' wheelchairs. The track and field uniforms for the Rio 2016 Olympics and Paralympics were developed with recycled Polyester "Aeroblades" which were small pyramid shaped protrusions on the sides of both the singlet and the tights of the uniform that help to make the runner more aerodynamic. However, before their races, the wheelchair racing athletes found that since the Aeroblades have a rubbery feel, they were unable to slide into their racing chairs when wearing the leggings. Some athletes chose to wear their own leggings, while others chose to wear the leggings inside out with the Aeroblades pressing into their skin.

Other more commonly seen apparel details in warmup apparel become problematic for wheelchair racing athletes as well. Details like hoods and pockets are useless to the athletes and make garments bulky so that it's harder to wear them in the chairs. Front pockets are unusable on jackets and pants, and if there are zippers it can become an uncomfortable pressure against the body. Whenever athletes are competing or training out on the roads, they are wearing helmets, therefore hoods are useless as well and can catch wind and slow athletes down when worn.

Glove concerns:

History of Racing Glove

I learned about the history of racing gloves from my interview with Paralympic wheelchair racing coach Adam Bleakney. Soon after athletes began racing in wheelchairs, they were looking for ways to protect their hands from the friction and force of the push rims. The earliest racing gloves were simply baseball gloves with athletic tape wrapped around areas of contact with the push rim. One of the first wheelchair racing coaches at university of Illinois, Marty Morse, helped develop the first commercially available glove. This glove is still manufactured today, it is a leather glove with foam fill similar to a boxing glove with a Velcro strap that keeps the hand in a fist position. Because of the large flat surface on the fist side of the glove, this greatly changed the biomechanics of the wheelchair racing hand and wrist motion. The flat surface of the glove minimized the excessive wrist motion and thus resulted in less wrist injury to athletes. However, the soft glove came with some drawbacks. Since the glove could slide against the hand and the push rim could slide across the surface of the glove, their was inevitably force lost in the athlete's interaction with the wheel. The soft foam also absorbed some of that force.

Because of this, athletes began developing their own rigid gloves out of thermoplastic materials like Aquaplast. These gloves were highly individual to each athlete, and athletes could experiment with different shapes and different styles of rubber for grip in different conditions. During this time, athletes generally went back to the grooved shape of glove because although it lent itself to more wrist injuries, it was found better for performance. With the grooved style

glove, the push rim isn't sliding at all against the surface of the glove and therefore there is much less force lost between the athlete pushing against the wheel. The DIY nature of these gloves had drawbacks though as well. It was impossible to exactly replicate an athlete's favorite gloves, and gloves couldn't be mirrored for the right and left side. In 2015, an athlete on the University of Illinois racing team remedied this by 3D scanning her gloves and printing them. She didn't expect them to be functional, but they functioned better than her previous gloves. Over the years she has developed her company, called Ingenium, and is the premier source for 3D printed racing gloves today. A timeline of the gloves can be seen in figure 21.

Figure 17 A history of wheelchair racing gloves

Current Racing Glove

The current and most commonly used racing gloves by elite athletes on the market are from Ingenium Manufacturing. The style sold on their website is titled "the chief" and is a flat style racing glove, but many of the elite athletes who train at University of Illinois have had their own gloves 3D scanned and printed in the grooved style. The gloves are printed from a PLA plastic and are filed with a honeycomb lattice fill in order to make the glove lighter weight. They feature a vented detail of 3 stripes on the back of the thumb. While athletes can customize how they would like the grip of the glove to function, most styles feature a grip style

covering the index and middle finger. The pushing surface of the glove has a hand cut rubber glued to the surface. Some styles feature an elastic band that comes across the dorsal surface of the hand to prevent the athlete from dropping the glove. A photo of the current gloves can be seen in the timeline above (Rausin, 2020).

Biomechanics

In my discussion with Adam Bleakney, I got a more complete breakdown of the biomechanics of wheelchair racing. The diagram in figure 22 is a better picture of the specifics of hand and wrist movement during the racing stroke. The biomechanics of the wheelchair

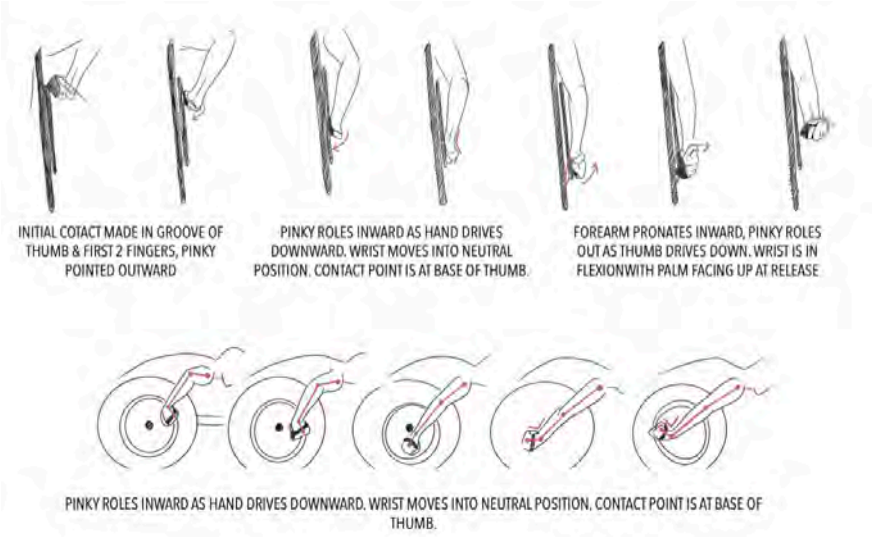


Figure 18 Diagram of wrist, arm, and shoulder biomechanics in the wheelchair racing stroke

racing stroke are complex. The stroke is comprised of 5 phases: contact, drive, release, lift & stretch, and acceleration. In the contact phase the athlete's hand grabs the push rim at approximately the 2:00 position of the wheel (if the wheel is pictured like a clock face). With the grooved style glove, the athlete makes contact by fitting the push rim into the groove of the glove and applying a tremendous amount of force inward toward the wheel and forward to push the wheel around. At the initial contact there is almost a feeling of pulling upward on the push rim, but this is only to create more of the inward force on the wheel. At this point the wrist is in a state of intense radial deviation. As the athlete begins to drive forward, force is coming from the primarily from the pectoral and shoulder muscles. The athlete drives the

wheel forward and in doing so, the wrist begins to straighten to it's normal position as the groove in the glove follows the curvature of the push rim. The athlete's arm straightens as they drive downward from the 2:00 to the 5:00 position. As the athlete moves into the final portion of the drive phase from the 5:00 to the 8:00 position, the forearm and wrist pronate inward to roll the push rim off the side of the thumb. The athlete strives to apply a greater amount of force in the last 3 hours of contact in order to drive the wheel effectively when it's released. As the athlete releases the wheel, they apply a flocking motion with the back of their thumb that puts the forearm into an intensely pronated state and the wrist into a state of ulnar radiation. Moving from the contact phase to the lift & stretch phase, the athlete's palms face skyward as they extend their arms backward to bring the hand into a high position to begin the acceleration phase. The acceleration phase begins at the highest point of the athlete's hand positioning and consists of the athlete moving their hand quickly into contact with the rim to apply the most force to the push rim of the wheelchair to begin the cycle again.

Common Injuries in Wheelchair Racing

Common injuries in wheelchair racing stem from the great amount of force being applied to joints that aren't designed to take that amount of force. "Our hips are here" coach Adam Bleakney told me in an interview, pointing to his shoulders. The most prevalent orthopedic injuries are overuse injuries to the wrist and shoulder, with injuries also occurring in the elbow and neck. These injuries can also stem from the daily activities of individuals in wheelchairs and the stresses applied to those joints. Transfers from wheelchair to other chairs can put a tremendous amount of strain on the shoulders, and pushing one's daily chair around all day can also stress the wrists.

The dynamic movements of the wrist throughout the stroke cycle can cause issues with tendinitis of the wrist and carpal tunnel syndrome. Commonly injured wrist tendons in wheelchair racing include the extensor digitorum longus, extensor carpi ulnaris, flexor carpi ulnaris, and abductor pollicis/extensor pollicis brevis (DeQuervain's tenosynovitis) (Yoshida, 2020). All the athletes I surveyed had dealt with wrist tendinitis at some point in their racing career. This final tendonitis issue, DeQuervain's tenosynovitis, is the most common injury

experienced by wheelchair racing athletes due to the hyper pronated state of the forearm and the ulnar deviation at the end of the propulsion cycle. For any wrist tendonitis injuries, the recovery process is similar. First the athlete should avoid any aggravating motions and take care to rest the affected tendons as well as take anti-inflammatory drugs and ice the area. As the inflammation gets under control, athletes can begin range of motion and isometric strengthening exercises. Athletes can also experience carpal tunnel syndrome from wheelchair racing due to the repetitive wrist extension and flexion. Overuse of the wrist extensor tendons can cause them to get inflamed and put pressure on the median nerve in the carpal tunnel of the wrist. This can cause pain and numbness in the hands. Treatment includes wearing a splint that keeps the wrist in a neutral position.

The other extremely common area of overuse injury for the wheelchair athlete is in the shoulder. Athlete in wheelchairs with spinal cord injuries rely entirely on the shoulder for all propulsion and weight bearing tasks throughout the day. The great range of motion in the shoulder that wheelchair racers rely on comes at the cost of instability in the joint. The shoulder joint relies on ligaments and musculature components for limiting it's movements (the rotator cuff). Those who rely on the wheelchair in daily life and then go on to use greater force to race their wheelchairs put a huge amount of stress on the joint that can result in muscular imbalances predisposing it to injury. The most common shoulder injuries include shoulder impingement or rotator cuff tendonitis and bicep tendonitis. These conditions involve pain and inflammation in the tendons around the rotator cuff and the subacromial bursae.

Finally, because of the rigid nature of the gloves and the fact that there is nothing between the 3D printed implement and the athlete's hand, acute injury to the skin of the athlete's hand can be an issue. Abrasion, laceration, and bruising can be problematic throughout the course of a marathon. This is most common on the knuckles & distal portions of the index and middle fingers since that is the area of the hand punching the push rim as seen in figure 20. Athlete's often accept this as part of the sport, and their hands often build up calluses

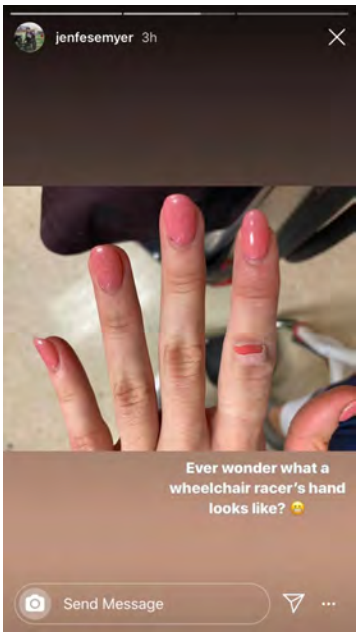


Figure 19 Abrasions on the fingers of a wheelchair racer

to deal with the repeated abrasion, yet missed strokes or odd hitting can lead to acute injuries that can impact the course of their racing.

Part 3: Ideation & Prototyping

Design Opportunity

I believe there is immense opportunity for product improvement specific to the needs of wheelchair racing athletes at every level, but starting with the elite athletes in the sport seems logical. The racing uniform, titled the Velox Kit, will be a uniform designed to the ergonomic, thermoregulatory, and protective needs of women's wheelchair racing athletes. Velox is a Latin word translating to "swift" in English, which seemed fitting for these athletes. It will feature a silhouette mapped to protect the body from the chair in key areas such as the lower body (which will have a full length legging) and a knit arm sleeve enhanced with Kevlar to keep it from ripping. The neckline of the singlet will be high to accommodate the coverage needs of the athlete. This must be balanced with details that help the athlete thermoregulate in the hot temperatures of the Tokyo summer. The singlet will feature laser cut ventilation along the stomach and tops of the thighs to help with airflow in the area. The sleeves will be a shortened ¾ length in order to minimize coverage and allow for airflow. All fabrics will be moisture wicking to help manage sweat. Silhouettes will be ergonomic to the working position of athletes, with leggings featuring a higher rise in the back and a lower front rise, and the singlet featuring a longer hem length in the back and shorter in the front. The graphics of the uniform will also be positioning informed, so that it is apparent what country the athlete is competing for while the athletes are competing. Fabrics must have a slick hand in order to facilitate an easy glide into the racing chair.

Following suit of the uniform, the warmup apparel will be titled the "Velox Warmup Kit". It is designed to be ergonomic and performance driven training apparel to protect racers from the elements. Many of the ergonomic details will be the same as the uniform. In the jacket, shoulder and arm mobility is paramount, as to not get in the way of the athlete as they train. This must be balanced with a fitted silhouette throughout the torso so that the jacket can fit into the straps of the wheelchair. The silhouettes will be minimal and performance driven, with the only pocket being a small card/key pocket located on the arm so it doesn't add to front of body bulk. The jacket will feature breathable, waterproof textiles to keep the athlete dry and comfortable in inclement weather. The sleeve cuff will be tight in order to not get in the way of

the athlete interaction with the push rim and graphics will be positioning informed, similar to the uniform.

Finally, the racing glove, titled the "Velox push glove" will protect the hand and minimize wrist strain without impacting performance. I believe the glove could be doing more for the athlete by way of injury prevention. Up until this point, much of the glove changes have been to the shape of the pushing surface and how it changes the biomechanics of the stroke at the initial contact. The grooved shape has been said to be a more efficient force transfer that lends itself to better performance but increased risk of wrist injury, while the flatter glove proves opposite. Since there is a great amount of force put into the stroke during the latter part as the athlete prepares to accelerate into the next stroke, I'd like to explore changing the mechanics of the release of the push rim to minimize injury. I'd like to do this by flaring the thumb on the outer part of the glove in order to minimize forearm pronation and encourage neutral arm positioning to not put the wrist in a vulnerable state. This will be coupled with a wrist support mechanism that will encourage the wrist to stay in a neutral position and minimize the extent of ulnar deviation at the end of the stroke (especially once the push rim has already been released and the deviation is due to momentum from the force). Along with these changes impacting the biomechanics of the stroke, I want to apply some protection to the fingers to minimize skin injury & abrasion. I will also take note from traditional footwear design and be applying a thin EVA foam layer to the fitting surface of the glove in order to allow for the glove to better conform to the shape of the push rim and facilitate force transfer without as much force from the shoulder pushing inward on the wheel. Since the conditions in Tokyo are expected to be humid, a tread pattern will be applied to the rubber to enhance the traction and lend a performance aesthetic to the glove. The design briefs for all three products are pictured in figure 23.

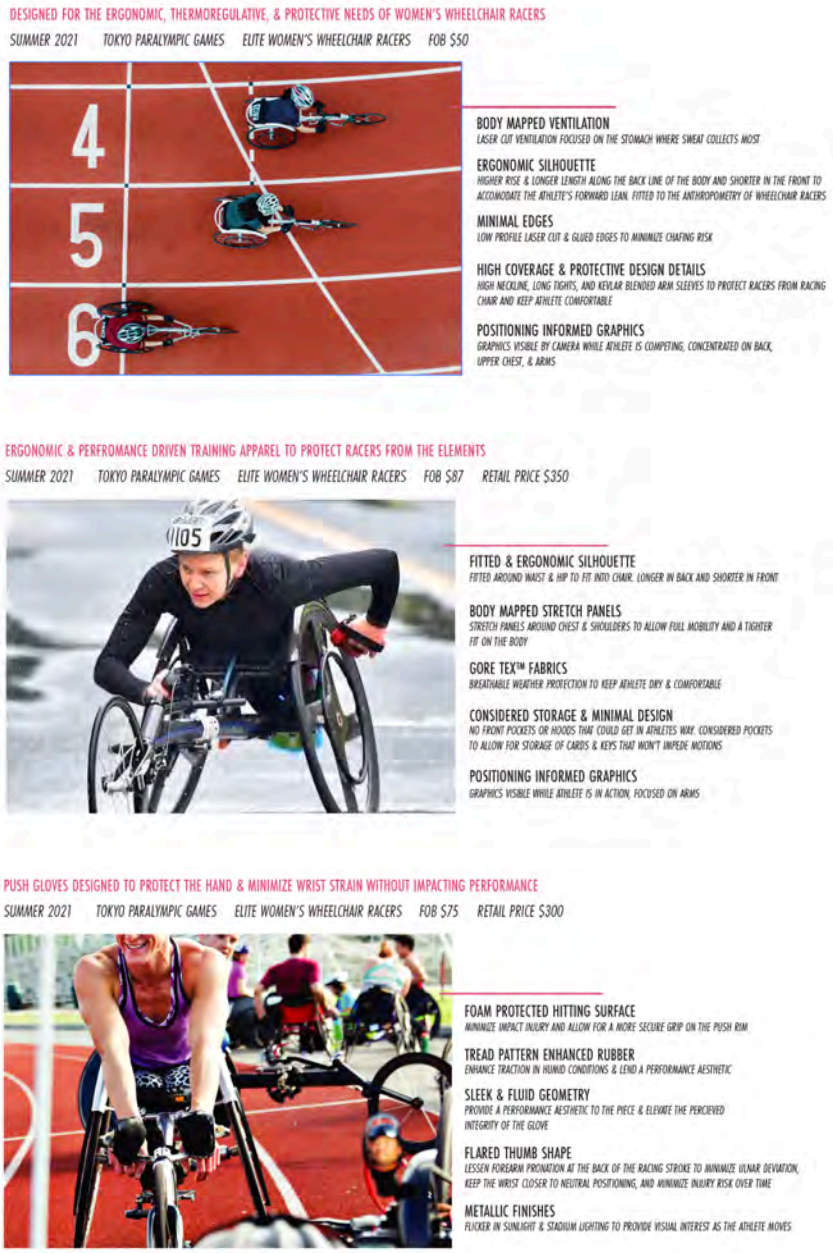


Figure 20 Design briefs

Apparel Ideation & Feedback

Apparel Ideation began with defining product priorities in each category so that I could compare ideation sketches against my priority list to determine effectiveness. The priorities for the uniform were as follows: ergonomic silhouette, minimize chafing risk, and assist in

Figure 24 first round apparel/uniform sketches

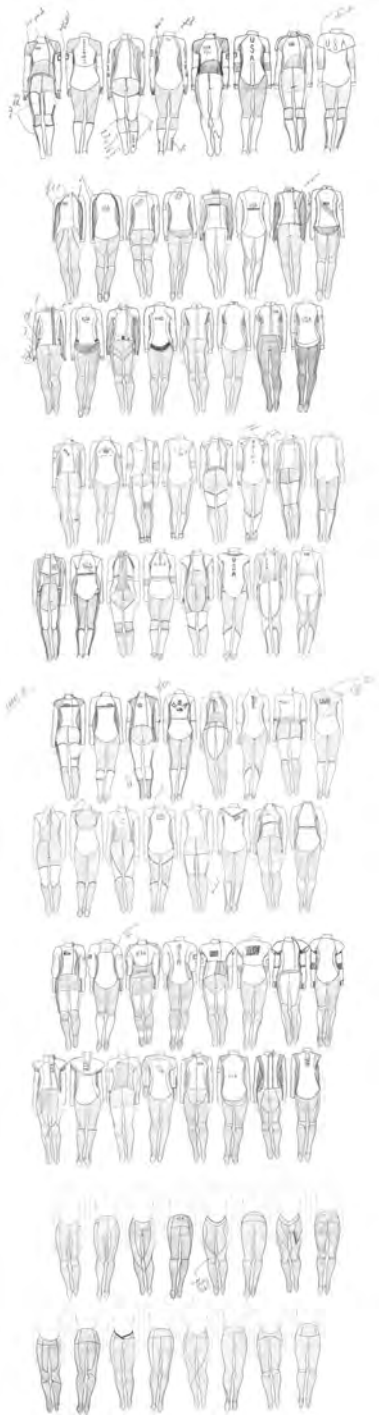


Figure 25 first round apparel/warm up sketches

thermoregulation for hot temperatures. Warmup priorities were: to allow maximum shoulder mobility, create an ergonomic silhouette, and utilize minimal details.

I then completed a rigorous round of sketching silhouettes for the uniform and warm up kit. Many different styles of neckline and other style lines were explored within the uniform. Within the jacket, different ways to enhance shoulder mobility were explored, both through textile manipulation and through changing sleeve styles. In the leggings, style lines and waistbands were explored that would be minimal and lay flat against the body. Paneling shapes were explored within the warmup leggings. The initial sketches for the uniform and warmup kits can be seen in figures 24 and 25 respectively.

From these sketches, a narrowed down page of sketches was developed that reflected a range of silhouettes that reflected the features outlined in the product brief and list of product

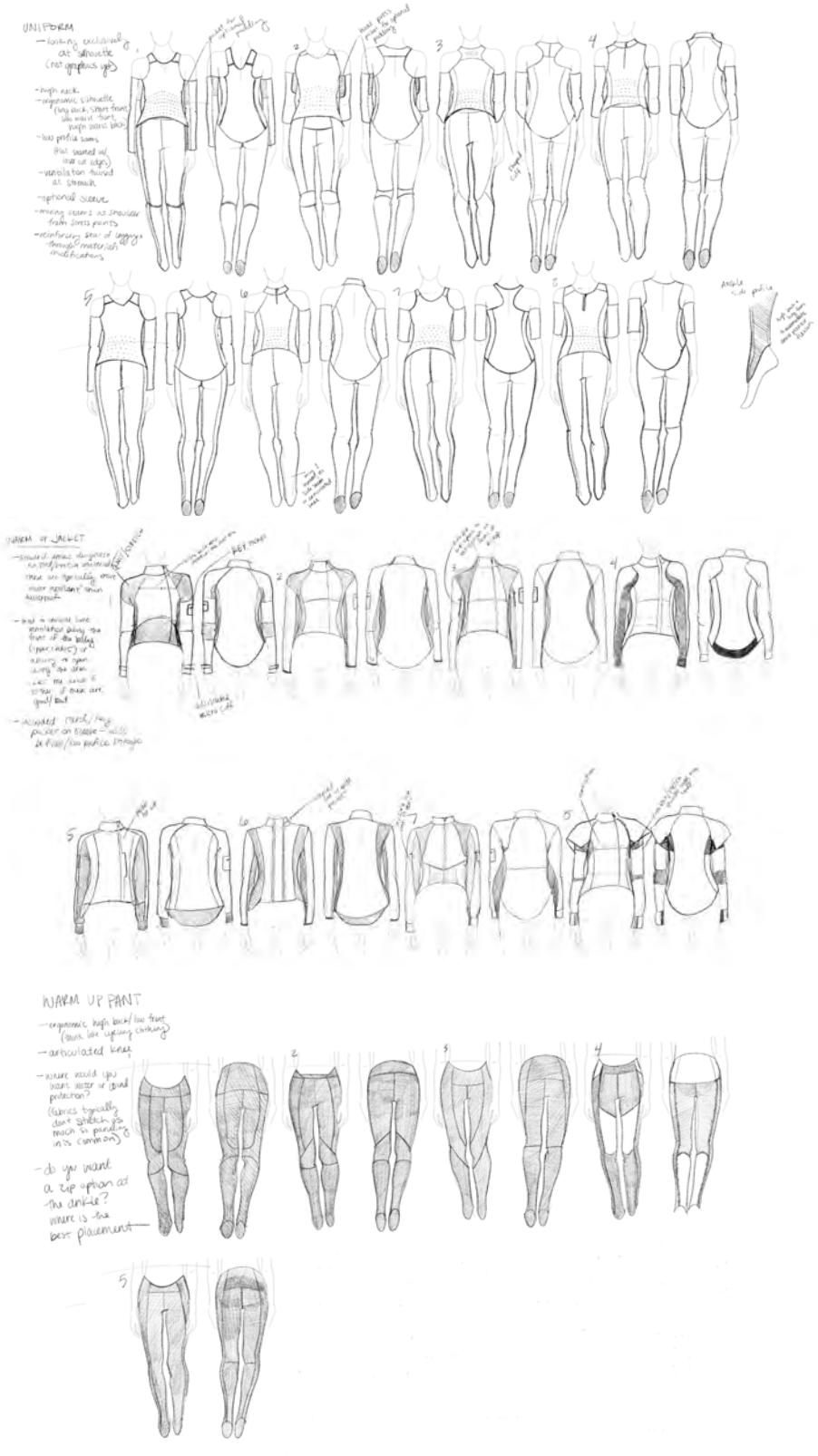


Figure 26 curated list of sketches sent to athletes for feedback

priorities (figure 26)I then sent these to athletes for feedback. Yen Haong was the only athlete

to get back to me, but her feedback was very valuable. With the singlets, she stated that the back seemed too long, and that for coverage, she would prefer having the leggings come higher, as they were less likely to get caught in the straps of her wheelchair. She also stated that her preference, as well as the preference of many of her racing peers, was for a simple racerback silhouette because she liked the way it enhanced their shoulder muscles. The preference for leggings was for silhouettes that were higher rise in the back, and featured zippers at the leg opening.

Based on this feedback, a final silhouette for each style was developed to move forward with into the prototyping phase (figure 27). These were iterations of sketches that were sent to the athletes and modified based on Yen's feedback.

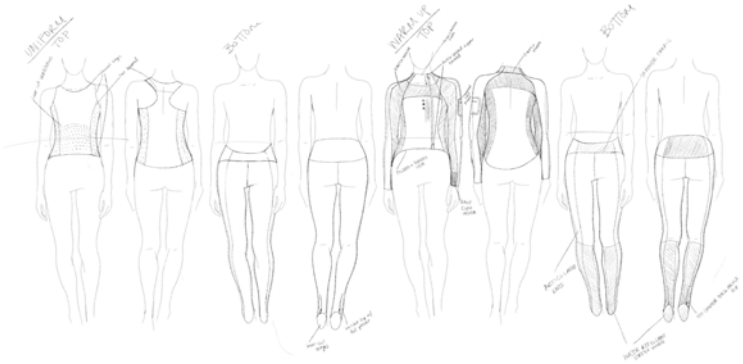


Figure 27 edited silhouettes

Apparel Prototyping

I began by prototyping the leggings. Immediately, I realized that the uniform leggings had too many complicated style lines and didn't comply with my goal to try and minimize irritation and chafing through minimal seaming. I altered the silhouette again to get rid of the seams around the ankle so there was just one side seam that was shifted to the front of leg. I also realized that the waistband was a bit too bulky for something that I wanted to lie extremely flat, so I engineered the waistband to be a fold-over style while still allowing for the contoured shape (getting rid of the line of serging around the top of the legging. I lengthened

the front panels to include the waistband fold-over as to eliminate the front horizontal seam of the waistband. I liked the aesthetic of these, but they felt like they lacked enough structure at the waist to hug the body and stay where they needed to, so I created the final prototype with a power mesh panel coverstitched into the back portion of the waistband. The folded part of the waistband is glued on the interior to allow it to lay flat against the body. Similarly, the hems are glued as well to eliminate bulk at the hem. The hemline is contoured around the foot to accommodate the flexion of the foot in the racing wheelchair. Uniform leggings prototypes can be seen in figure 28.

Figure 28: Warmup leggings prototypes and waistband iterations

For the warm up leggings, I focused a lot on the style lines of the legging itself, and where the water repellant and windproof paneling should be placed. Yen had given feedback that when training in the rain, her ankles and lower legs are often the places that get wet, so it keeping a solid portion of the lower leg covered with the windproof and water repellant fabric was paramount. Balancing the paneling with the necessary stretch for fitting was also priority. I played with waistbands a bit here as well, and readjusted the silhouette of the waistband once I'd settled on a style for the uniform so that the two would tie together better. I also experimented with cuff types and landed on a

Figure 29 Warmup leggings prototypes

laser cut neoprene cuff that would be snug against the ankle as well as tie to the cuffs on the jacket. These can be seen in figure 29.

The singlet prototype is very simple. I created one initial prototype, then created a secondary one which had an adjusted hemline shape, as well as properly finished edges (folded and glued to keep them extremely minimal). After creating this style, I realized that I wanted to move the shoulder seam downward in order to take some of the stress off of it, so I drew in where the new seam should go. Singlet prototypes are pictured in figure 30.

Figure 30 Singlet prototypes

For the jacket, I began by creating an initial simple prototype to draw style lines onto and adjust fitting and silhouette. From that, I created new patterns and created a prototype from the same fabrics I'd be utilizing in the final garment so I could see how they interacted. The collar on this prototype was still needing adjustment however, so I brought the neckline up to simplify the shape. I experimented with finishing techniques on the cuffs, hemline, and collar. Further prototyping is needed to continue with finishing techniques on the hem, cuffs, and collar, as well as continued adjustment of the back style lines (I'd like to adjust to better

Figure 31 Jacket Prototypes

mirror the front of the garment to eliminate the extreme curve on the back). Jacket prototypes are pictures in figure 31.

Glove Ideation & Feedback

Figure 32 Glove ideations, textile and rigid/textile combo

I began glove ideation similar to apparel ideation, in that I created a list of priorities to compare my sketching against. The priorities for the glove were: encouraging neutral positioning of the forearm and wrist, performance aesthetic, and ease of donning & doffing. I then began sketching all types of silhouettes, experimenting with form for the rigid piece, as well as what a textile piece would look like for the glove. In wanting to keep with the spirit of being inspired by footwear design, I had initially planned to incorporate the textile piece into the rigid piece of the glove, similar to an upper and midsole. However, upon further thought and investigation, I realized that this may prove difficult to get on and off and would leave athletes in an awkward state if they needed to remove the glove while racing.

Once settling on this, I ideated into what a purely textile glove would look like and how I could support the wrist and encourage it towards a neutral position. Some of these sketches can be seen in figure 32. I discussed with Nike Biomechanist Shannon Pomeroy on how they mitigate tendon injuries in footwear design to see if there were things I could implement into the design of my glove. She talked about how rigid textile uppers are utilized in cleats to mitigate turf toe injuries and how a similar method could be used in stabilizing the side of the hand opposite the direction of movement I was discouraging to keep the wrist neutral. I settled on a basic silhouette to take forward into prototyping that had the back cutout and featured a strap around the wrist that was wider and connected at the thumb side of the hand in order to discourage ulnar deviation.

After some discussion with Shannon, I settled on the shape for my rigid piece which featured a flared silhouette at the thumb release to minimize forearm pronation. This is similar to how certain running shoes strive to offer greater pronation control and stability. I began 3D modeling around the shape of the current Ingenium grooved glove silhouette. I wanted to keep the ergonomic feel of the handle and thumb cavern, while updating the geometry to be much sleeker and more fluid. Some of the ideations around the form of the glove can be seen in figure 32.

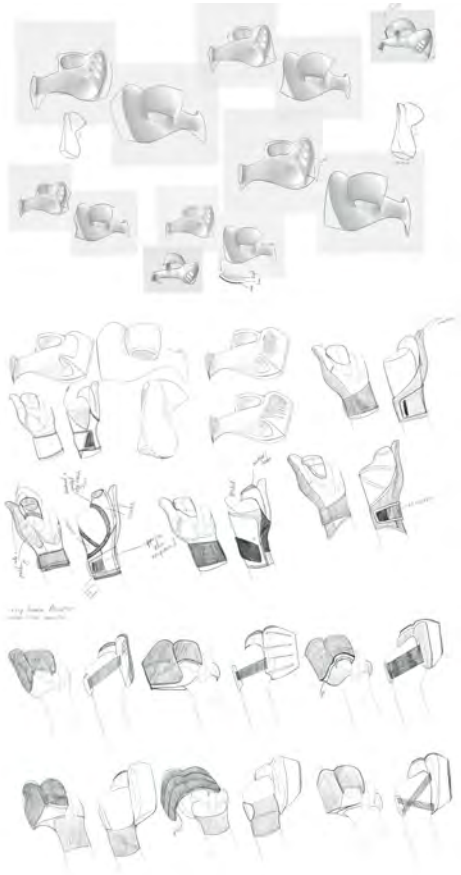


Figure 32 Glove form ideation

Glove Prototyping

I began my prototyping in the 3D modeling space in order to create a 3D print in a timely fashion to begin adjustments. In order to do this I had to learn the modeling software Fusion 360 which is known for being able to model organic forms well. The 3D printed prototype can be seen in figure 34.

I began prototypes of the soft glove by taking apart a pair of Nike weight lifting gloves to explore how they utilized suede and padding to protect the hand. I then began patterning my own gloves and pinned the strap in several different areas to explore it's effect on minimizing wrist deviation. Throughout this I realized that the style with the back cutout didn't have adequate coverage to stabilize the strap and provide adequate support so I adjusted it to have full dorsal coverage. I then explored materiality and style lines within the

Figure 33 Soft Glove prototyping

Figure 34 Rigid Glove 3D prototype

glove. I explored cuff length (lengthening it too much, then needing to add a wider cuff to add length back), and materiality affecting fit. The final proof of concept prototype is still a bit tight on the hand, so further prototyping is needed for a more precise fit. These prototypes can be seen in figure 33.

Validation

For validating the apparel, I used two methods. The first was a virtual fitting I completed with Paralympic athlete Susannah Scaroni, who had offered useful insight during the design process. She tried on the uniform and had high praise foe the pieces. Some of her favorite aspects were the high neck on the singlet, the minimal backline of the singlet, the slick material on the leggings, and the ankle zippers that allowed for a tight fit around the ankle. For the weatherproof apparel, the rain jacket was the star of the fitting. It was immediately apparent that it offered mobility superior to any of her other options, while still remaining sleek and lightweight. The training leggings were the only piece that required adjustment, as they turned out a bit too short since the water repellant stretch woven didn't stretch as much as the 4 way stretch of the uniform leggings.

The virtual fitting with the soft glove was more critical, but ultimately served in creating product better suited to athlete needs. Although the glove had been validated by a Nike biomechanist in the idea that it would minimize ulnar and radial deviation and encourage neutral wrist positioning, athletes Arielle Rausin and Susannah Scaroni felt that it might hinder movements too much, becoming detrimental to performance. While we began throwing around ideas to make the glove less restrictive, the general feeling I gathered was that ultimately it wouldn't be worn. However, a comment they made about the current lack of thermal hand protection that interfaces with their push gloves led to a discussion that impacted the final product. We discussed the different needs of the glove, having a tight fitted fabric on the fingers grasping the glove, a thermally protective fabric on the dorsal surface of the hand

and exposed fingers, and grip to help securely grasp the glove. These needs are mapped out in figure 21. Since athletes lack proper thermal protection that interfaces with their push gloves,

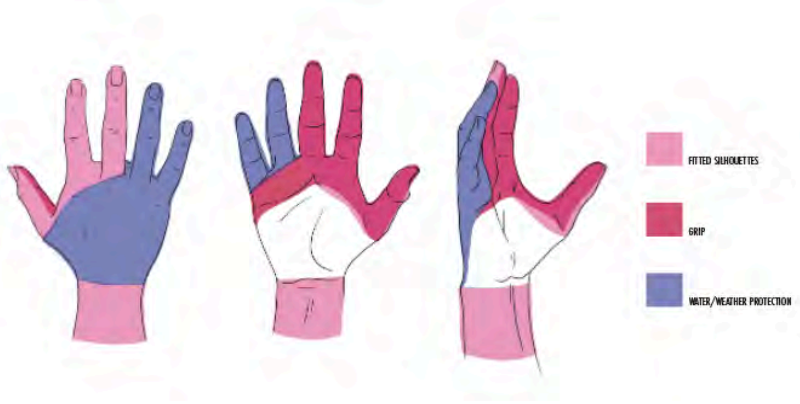


Figure 21 Hand mapping for thermally protective glove

they often wear latex gloves or cut the fingers off of cheap gloves to offer protection.

Based on this feedback I sent sketches to both Arielle and Susannah of several options of glove style, exploring having glove gripping fingers exposed versus covered, and different cuff styles. These sketches are visible in figure 22. From there I prototyped based on sketching, exploring materials and fit and settled on a lobster mitt style with a ribbed cuff and silicon grip on the interior where it grabs the push glove. When shown pictures of prototypes, athletes like the updates and felt that although simple, it would solve a huge pain point for them.

The second form of validation for the apparel was a wear test of the uniform outfit and the training outfit. Susannah wore the uniform for a workout in her racing chair, indoors on her roller. The apparel performed well in the wear test, and she said of the items that they were "really awesome, and different than her current options." She wear tested the training apparel the following day in a rainy outdoor workout. The workout was 60 minutes long and the apparel performed well for the entirety of it, giving full shoulder mobility. She liked that

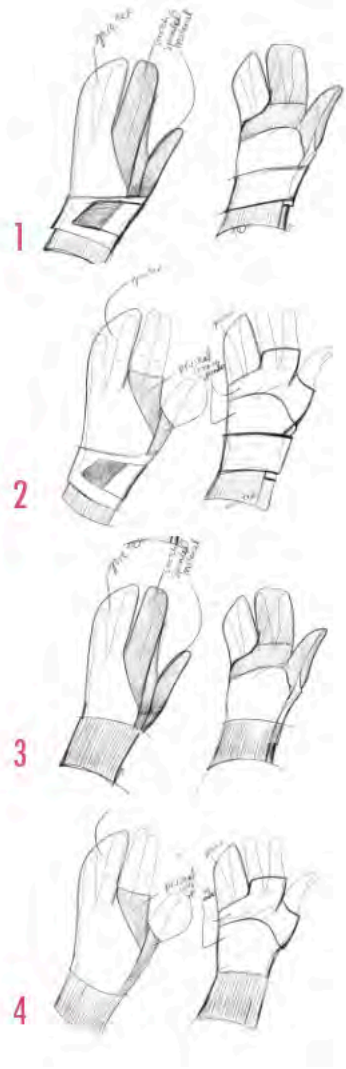


Figure 22 Thermal Glove Sketches

the jacket was lightweight and sleek as it didn't add bulk to her racing chair.

Finally, validation for the push glove began during the sketch process. Throughout, I worked with biomechanics professor Shannon Pomeroy to make sure the changes I was implementing would have the desired result in minimizing forearm pronation and ulnar deviation. Once the form had been sketched, modeled, and printed, it was sent to athletes for validation. Initially they were hesitant. Arielle felt that the edge of the glove on the thumb side would get stuck or caught as she tried to release the push rim. However, she continued working with me to adjust the fit of the glove enough that she could wear test it. The wear test proved initial hesitation false. Susannah said that it felt as though the glove was having the intended result in the biomechanics sense since it minimized forearm pronation, but she also felt that the glove would be beneficial for climbing hills since the increased surface area meant that the glove was in contact with the push rim for longer on each stroke. Arielle was also surprised at how smooth the stroke with the glove felt, and she said there was a smooth release as well. A major goal of the glove was to update the performance aesthetic, and the new shape was received well aesthetically by athletes.

Graphic & Color Inspiration/Ideation

The graphic and color inspiration for the project stems from a 90s nostalgia. I looked to my mom's Olympic uniform and apparel from the '92 Olympic games as reference and inspiration. Each of the product categories have a mood board, but they tie together in mood

and color palette. Figure 21 shows the mood board for the uniform.

Figure 23 Uniform Palette & Mood Board

The trend handle for the racing kit is "New Nostalgia" and the trend description is this:

> *Emerging from a global pandemic, we're reminded of the true beauty of the Olympic and Paralympic games. Without competitive sport, we've looked to games past for nostalgia-– not for aggression or competition, but for the togetherness that our favorite teams bring. We've also craved technological advancements, both for health and safety, and as a sign that society continues forging ahead. "Ad astra per aspera", to the stars through difficulty, is the phrase of the day, with the stars of the USA symbolizing resilience–our ability to rise above and come together. A juxtaposition of retro and new, young and old, and coming together and rising above. Showcasing the true beauty of the games, we celebrate the old and welcome in a brighter and more inclusive future.*

Figure 22 shows the mood board for the training apparel, which holds a similar feeling and color palette, with the addition of a magenta hue.

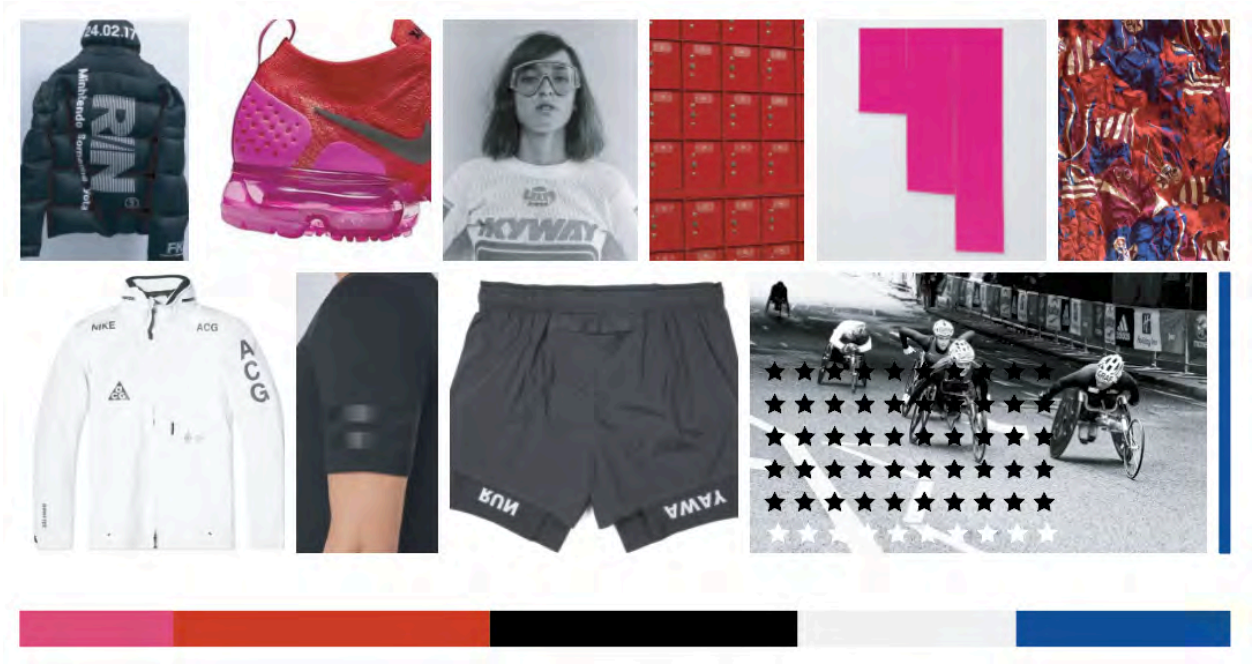


Figure 24 Training Apparel Mood Board & Palette

The continuation of trend is titled "Inspired by '92":

> *A lively spirit inspires the mood and color here. Performance has become so serious, As athletes strive to cut seconds from personal bests, we forget the reason we started competing in the first place. Patriotic tones of red, white, and blue are complemented by a bold and playful magenta hue, a nod to the '92 opening ceremonies ensemble. Silhouettes remain sleek and functional to allow athletes to compete at their best, while graphics strive to remind us of the play that originally inspired them to compete.*

Finally, the mood board for the push gloves is pictured in figure 23. It takes the magenta hue from the training palette and incorporates it with eye catching iridescent finishes to adorn the hardgoods pieces. These metallic finishes will flicker in the sun when athletes move their wrists through the dynamic motions characterizing wheelchair racing biomechanics.

Figure 25 Push Glove Mood Board & Palette

After several rounds of ideation surrounding prints, graphic placement, tread patterns, and other factors, the following applications of graphics were settled upon, featured in Figure 24.

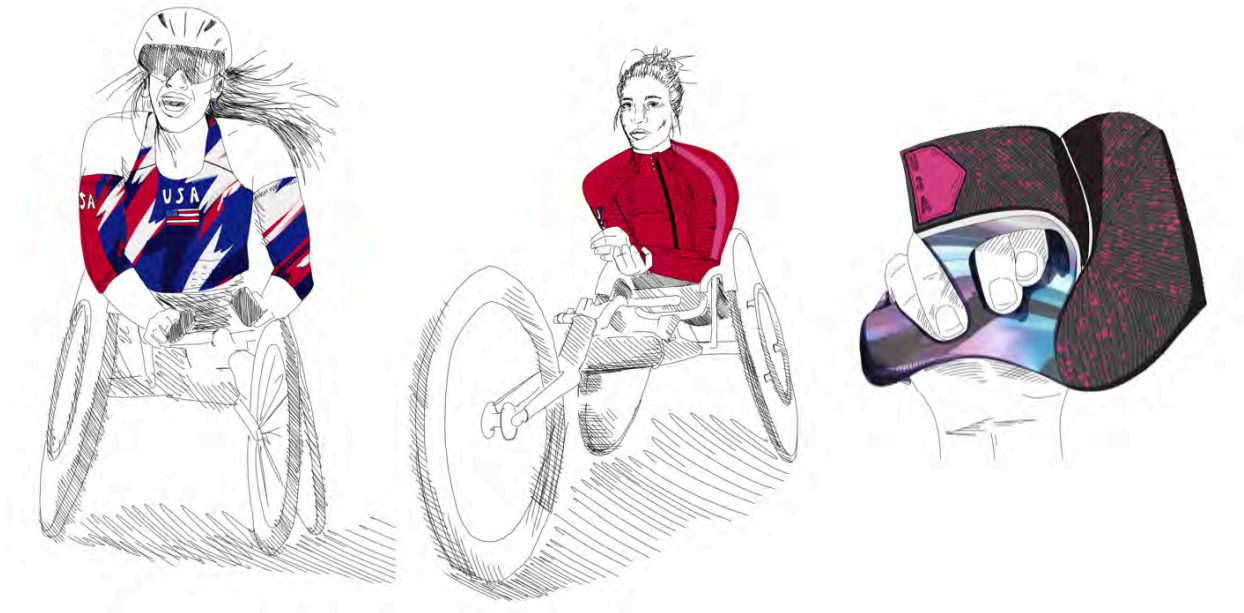


Figure 26 Color & Graphic Application for uniform, Training Apparel, and Push Glove

The colors and 90s inspiration taken into the graphics of the collection were also taken into consideration when branding the project and creating packaging for the collection.

Presentation & Product Marketing

On completion of the final prototypes, I conducted a photoshoot with photographer Layla Alazawy and athlete Susannah Scaroni. Due to the conditions of the pandemic, I was unable to travel to Illinois for the photoshoot, but instead sent detailed creative direction and shot lists to Layla for execution. For creative direction, she was instructed to go for a nostaligic 90s aesthetic in line with the mood boards. Photographers referenced were Emily Maye for Tracksmith and Emily Oberg for Sporty & Rich. These photos can be seen in the process book.

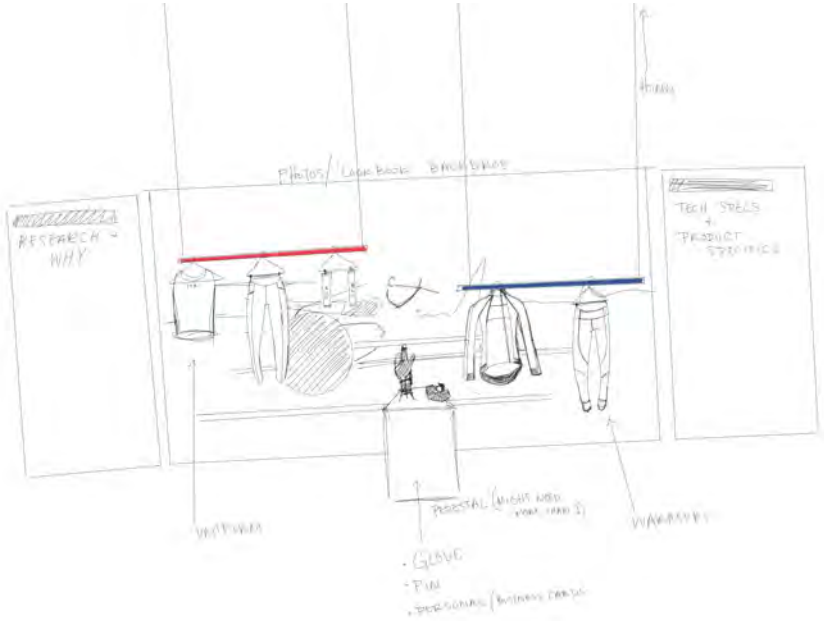


Figure 35 Intended layout for the thesis presentation

Before the pandemic changed the conditions under which the project would be presented, I had planned to utilize the photos for a large display to showcase the prototypes at final review. I'd planned to have a display that features the apparel hung on hangers with the display backed by large images acting as a lookbook for the apparel. This would have been accompanied with boards on either side that are smaller and feature a brief bit of the research behind the product (a lot of the "whys" that went into the design decisions I made as well as some story around the importance of the product) as well as another that features technical drawings of the garments with some of the callouts about the features and benefits. For the glove I'd have a hand mannequin for the soft piece to showcase the form, then show it on a pedestal next to the rigid piece. Figure 35 is a drawing of what I'd envisioned for the space.

Marketing for the project centered around utilizing the beautiful imagery for social media and media requests. Susannah was able to utilize the photos to reach out to her community of wheelchair racing athletes and promote the project, and I was able to reach other parts of the running community through my platform. A writer from Runner's World magazine saw the project and will be utilizing the photography along with interviews of myself and the athletes I worked with to further promote the project. If the project were to be taken on and implemented, the imagery could be used for media highlighting the importance of designing adaptive uniforms and training apparel for elite athletes.

The product packaging and branding has several pieces. The apparel would be branded with an informative hang tag highlighting the unique features & benefits of each of the pieces, as well as the ethos behind the product name and athlete outcomes. The hang tags are pictured in the process book as well, along with ideation to get to the final. Athletes would receive the push glove in a lovely box with a magnetic closure that would act as protection for the gloves after they were done with use. The interior of the lid is informational, highlighting some of the product benefits as well as how it's held. Athletes would also receive a drawstring bag to carry race day essentials. The bag is simple, with drawstring straps looping through the top of the bag to open and close, but it has a drawcord pull that can change strap length so it can comfortable hang on the back of a wheelchair. The front of the bag has mesh pockets to house the push gloves separately from apparel.

Finally, because the uniforms and apparel are so unique, I felt that the racers deserved branded product that was also unique to their sport of wheelchair racing. I developed a graphic of a wheelchair racer to apply to a simple cotton sweatshirt that would act as a comfy recovery or travel piece.

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Appendix A: Interview Questions

Adam Bleakney–Wheelchair Racing Coaching Questionnaire

How did you get into coaching wheelchair racing? How long have you been coaching?

What are some ways that the sport has changed over the course of time you've been coaching? What has stayed the same?

In coaching collegiate and post-collegiate athletes, how does their training develop over the years? What are athletes focusing on when they first start out vs. when they've been racing successfully for years?

What are some characteristics of successful athletes you've coached?

Can you walk me through the basics of correct form in wheelchair racing? i.e. what is body positioning like, what is stroke cycle like, how does the hand interact with the push rim etc... Does this change based on race distance or terrain or with specific athletes?

What types of drills and strength exercises do you work on in practice and how do these translate to racing?

What are some of the difficulties of mastering the form of wheelchair racing and how do athletes practice this?

What are some common types of workouts you guys will do?

How are typical training cycles structured? What does a buildup for the marathon look like?

How do you guys train for specific racing conditions? (Heat, specific terrain, altitude, etc…)

What are some common overuse injuries seen amongst athletes? How do you treat these?

Are there common acute injuries that can happen whilst training and racing? What are they?

Are there ways that an athlete's equipment can cause injury?

How can an athlete prevent injuries?

What does the time post-marathon or post-race look like? How long does an athlete take to recover off the marathon and what measures do they take to aid this recovery?

Are there cross-training activities athletes will partake in?

What features do you think are important in the design of wheelchair racing specific apparel? What features are important in racing uniforms specifically?

What have been some of the biggest innovations in general in the sport of wheelchair racing in terms of equipment? What barriers have there been to innovation?

Susannah Scaroni, Yen Haong,–Wheelchair Racing Athlete Questionnaire

Briefly explain your background in racing. When did you start? How long have you been racing? What events did you start in? When did you start racing marathon?

What is the nature of your disability (paralympic classification & short description) Do you use a wheelchair to get around during your everyday life when you're not training?

What does a typical training week look like for you currently? How do different training cycles vary throughout the year?

How many marathons have you done? How many Paralympics have you been a part of?

How do you approach racing a marathon? Are you breaking up the course into specific segments, having different focuses throughout? Is there a lot of surging and tactical play or is it more steady?

Have you ever suffered an overuse injury from racing/training? Have you ever suffered an acute injury from racing/training?

What are common injuries you see in your sport (overuse and acute)?

What measures do you take when recovering from an overuse injury? (disregard if you've never been injured)

•••

Right off the bat, What features do you think should be considered in the design of apparel for wheelchair racing, both training, racing, and recovery?

When looking for tops for wheelchair racing & training, what do you look for? (i.e. are there specific necklines, sleeve/strap types, silhouettes, torso & sleeve lengths etc… that work better than others?)

What are some problems you have with tops in regards to wheelchair racing?

When you're looking for bottoms for wheelchair racing & training, what are you looking for? (i.e. silhouettes, leg lengths, cuff type, pocket placement, waistband types, waist rise, etc… that work better than others)

What are some problems you have with bottoms in regards to wheelchair racing?

What lengths of shorts are most comfortable? What lengths of pants? What is your preferred race bottom length?

Are there specific things you look for in racing apparel that you don't look for in training apparel?

What are your favorite and least favorite pieces of apparel you've worn to race and train in? Why? (bring examples if possible!)

Have you ever altered clothing to suit your needs as a wheelchair racing athlete? How? (Please bring examples if possible?

What specific brand/sizes/models are your favorite tops/bottoms/jackets/bras for training or racing apparel in terms of fit? (Bring examples if possible!) (these might be the same examples as the previous question)

Do you have any superstitions around clothing that is "lucky" for racing?

•••

Where do you sweat the most when you're racing in a wheelchair? Does the seated position create areas where it's hard to manage sweat? (mark in areas where sweat is most apparent when racing, catered to your racing position)

Are there any specific areas where chafing and/or irritation is common in wheelchair racing? (Mark on diagram) How do you deal with this? Are there areas where you apply body glide or another lubricant?

Where do you pad the body when you race and train?

•••

When looking for recovery apparel (apparel worn immediately following a hard training session or race) what features do you look for?

Are there any features you avoid when looking for recovery apparel?

What are some common fit issues regarding recovery apparel?

What specific brands/sizes/styles are your favorite pieces of recovery apparel for tops/bottoms/jackets etc…? (Please bring examples if possible!)

What modalities do you use to recover after a hard training session or race? Do you feel there are any modalities that are harder to maneuver because of mobility limitations?

•••

What did you receive for uniforms and recovery apparel as a part of Team USA?

What pieces of the uniform did you end up racing in? What did you like about these pieces?

What didn't you like about the uniform?

Are there problems or concerns unique to wheelchair racing that you feel your Team USA uniform didn't cater to?

What did you think about the other apparel given to you by Team USA? What did you like about the other/recovery apparel?

What did you dislike?

•••

What are the other items you're wearing while racing that aren't uniform? (equipment & accessories)

What gloves do you currently wear to race? Are they the same gloves you wear to train?

What are the most important features you look for in a glove for racing purposes?

Are there any issues you have with the gloves you currently wear to race and/or train?
Do you ever get any pain in your hands from racing and training? Mark on the diagram where this pain occurs and describe.

Are there any features you would add or take away from the gloves you wear to race and/or train?

Do you ever get blisters or abrasions from the gloves you wear to race in?

Are there ever issues with sweat interacting with your gloves?

What is the biggest change to wheelchair racing you've seen over your time as an athlete (both in equipment and in the sport itself)?

Arielle Wheelchair Racing & Glove Design Questionnaire

Briefly explain your background in racing. When did you start? How long have you been racing? What events did you start in? When did you start racing marathon?

What is the nature of your disability (paralympic classification & short description) Do you use a wheelchair to get around during your everyday life when you're not training?

Have you ever suffered an overuse injury from racing/training? Have you ever suffered an acute injury from racing/training?

What are common injuries you see in your sport (overuse and acute)?

What measures do you take when recovering from an overuse injury? (disregard if you've never been injured)

•••
Right off the bat, What features do you think should be considered in the design of apparel for wheelchair racing, both training, racing, and recovery?

When looking for tops for wheelchair racing & training, what do you look for? (i.e. are there specific necklines, sleeve/strap types, silhouettes, torso & sleeve lengths etc… that work better than others?)

What are some problems you have with tops in regards to wheelchair racing?

When you're looking for bottoms for wheelchair racing & training, what are you looking for? (i.e. silhouettes, leg lengths, cuff type, pocket placement, waistband types, waist rise, etc… that work better than others)

What are some problems you have with bottoms in regards to wheelchair racing?

What lengths of shorts are most comfortable? What lengths of pants? What is your preferred race bottom length?

Are there specific things you look for in racing apparel that you don't look for in training apparel?

What are your favorite and least favorite pieces of apparel you've worn to race and train in? Why? (bring examples if possible!)

Have you ever altered clothing to suit your needs as a wheelchair racing athlete? How? (Please bring examples if possible?

What specific brand/sizes/models are your favorite tops/bottoms/jackets/bras for training or racing apparel in terms of fit? (Bring examples if possible!) (these might be the same examples as the previous question)

Do you have any superstitions around clothing that is "lucky" for racing?

•••

Where do you sweat the most when you're racing in a wheelchair? Does the seated position create areas where it's hard to manage sweat? (mark in areas where sweat is most apparent when racing, catered to your racing position)

Are there any specific areas where chafing and/or irritation is common in wheelchair racing? (Mark on diagram) How do you deal with this? Are there areas where you apply body glide or another lubricant?

Where do you pad the body when you race and train?

•••

When looking for recovery apparel (apparel worn immediately following a hard training session or race) what features do you look for?

Are there any features you avoid when looking for recovery apparel?

What are some common fit issues regarding recovery apparel?

What specific brands/sizes/styles are your favorite pieces of recovery apparel for tops/bottoms/jackets etc…? (Please bring examples if possible!)

What modalities do you use to recover after a hard training session or race? Do you feel there are any modalities that are harder to maneuver because of mobility limitations?

•••

Walk me through your own glove design project.

What were some of the biggest surprises of the project?

What were some of the hardest parts?

Would you change anything about the initial design process?

Has the design of the glove changed or developed since the initial design?

Where do you see the design/your company going forward?

Other than the individualized hand scans, how do you tailor the gloves for each athlete?

Are there ways to tailor the gloves for different conditions? (i.e. temperature, precipitation, etc…)

Are there ways in which you can minimize injury through glove usage/design?
Are there any problems still with the current glove design (either in use or manufacture)?

Are there different needs in a glove in training vs. racing? Is there potential for separate equipment?

Ann Yoshida–Occupational Therapist Questionnaire

Briefly explain your background as a Paralympian and an occupational therapist.

Shoulder impingement syndrome, bicep tendinitis, and other shoulder injuries, are some of the most prevalent injuries among wheelchair racing athletes. Can you explain the mechanics of how this type of injury occurs over time?

What muscles are being stressed in this type of injury?

How might an athlete prevent this type of injury through strengthening routines or changes to daily habits?

Once an athlete has a shoulder overuse injury like Shoulder Impingement Syndrome, what measures should they take to recover? Can they rest the shoulder while continuing to train and continuing to use their daily wheelchair for mobility?

Hand Injuries are also common in wheelchair racing–soft tissue injuries and weakness/numbness in the hands have been reported. Can you explain the mechanisms of why this would occur in wheelchair athletes over time? What in the hand is experiencing trauma enough to cause these injuries?

How could an athlete prevent this?

Once an athlete is experiencing soft tissue hand injuries or weakness/numbness in the hands, what can they do to recover?

In an athlete interview I had, she mentioned neck issues are also common amongst athletes because of the forward positioning of the body (but obviously needing to see forward some). What are the mechanics of how this occurs and what muscles are involved?

How can an athlete prevent this type of injury?

Once an athlete has a neck pain injury, what can they do to recover?

Do you think there's any questions I'm missing or information I should know about common injuries in wheelchair athletes that I should know going forward?

As a Paralympian yourself, what are the biggest challenges to recovering from a sports related injury?

What was you experience with Team USA like? What uniforms and apparel did you receive? How did it fit? Was it suited to your sport specifically?

How do you alter products to fit your needs as a para athlete?

VELOX

ERGONOMIC. ADAPTIVE. PERFORMANCE.

SARAH KLECKER // UNIVERSITY OF OREGON // SPORTS PRODUCT DESIGN

VELOX *DESIGNER INTRO*

WE LINE UP ON THE SAME START LINES WITH THE SAME GOAL: TO GET FROM START TO FINISH AS FAST AS POSSIBLE & WE GET THE SAME JOY FROM COMPETING IN OUR SPORTS

I GREW UP RUNNING AROUND SEVERAL OF MINNESOTA'S 10,000 LAKES, RAISED BY AN OLYMPIAN & AN AMERICAN RECORD HOLDER IN A HOUSEHOLD THAT LIVED & BREATHED SPORT. I RECEIVED MY DEGREE IN APPAREL DESIGN FROM THE UNIVERSITY OF MN, WHERE I COMPETED ON THE TRACK & CROSS COUNTRY TEAMS. A PASSION FOR CREATIVE PROBLEM SOLVING & WORKING WITH ATHLETES BROUGHT ME TO PORTLAND TO PURSUE SPORTS PRODUCT DESIGN, WHERE I CONTINUE TO RUN & COMPETE. MY PASSION FOR DESIGN & ATHLETIC EXCELLENCE KEEP ME INSPIRED TO SERVE ATHLETES IN THE BEST WAY POSSIBLE.

IN CHOOSING A PROJECT TOPIC, I OFTEN GOT THE QUESTION "WHY WHEELCHAIR RACING?" MY ANSWER? I'VE REALIZED THAT MY PASSION FOR SPORTS PRODUCT DESIGN GOES BEYOND MY OWN LOVE OF RUNNING & INSTEAD COMES FROM WANTING TO ENABLE INDIVIDUALS IN SPORT TO EXPERIENCE THE SAME JOY THAT I HAVE AS AN ATHLETE.

VELOX *WHY?*

CURRENTLY WORLD CLASS WHEELCHAIR RACING ATHLETES AT THE PARALYMPIC LEVEL ARE WEARING UNIFORMS THAT AREN'T DESIGNED FOR THEIR SPORT

INSTEAD, THEY WEAR UNIFORMS AND TRAINING APPAREL DESIGNED FOR STANDING TRACK ATHLETES THAT DON'T MEET THEIR UNIQUE NEEDS. ALONG WITH THIS, THERE IS A STIGMA THAT ASSOCIATES WHEELCHAIRS WITH TRAGEDY & ILLNESS—MANY SPORT SPACES & PRODUCTS ARE STILL EXCLUSIONARY TO ATHLETES IN WHEELCHAIRS. THERE IS NO ATHLETIC APPAREL ON THE MARKET SPECIFICALLY DESIGNED FOR WHEELCHAIR ATHLETES.

BY DESIGNING FOR THE ELITE WHEELCHAIR RACING ATHLETE, WE OPEN THE DOOR FOR FURTHER ADAPTIVE PRODUCT TAILORED TO THE NEEDS OF WHEELCHAIR USERS & BROADEN THE LIMITED CULTURAL PERCEPTION OF WHAT IT LOOKS LIKE TO BE AN ATHLETE.

VELOX *PROJECT*

"VELOX" IS A LATIN WORD MEANING SWIFT

THE VELOX COLLECTION STARTS WITH THE ATHLETE AT IT'S HEART. THE APPAREL IS THE FIRST OF IT'S KIND, DESIGNED IN ACCORDANCE WITH THE UNIQUE ERGONOMIC, PHYSIOLOGICAL, & MOBILITY NEEDS OF THE ELITE WOMEN'S WHEELCHAIR RACING ATHLETE. THE VELOX RACING GLOVE REINVENTS THE PUSH GLOVE FORM TO ENHANCE PERFORMANCE AESTHETIC & MINIMIZE WRIST INJURIES COMMON IN WHEELCHAIR RACING.

VELOX *ATHLETE OUTCOMES*

THE GOAL OF THE VELOX COLLECTION IS TO GET OUT OF THE WAY OF THE ATHLETE & ALLOW THEM TO COMPETE AT THEIR BEST

FOR THE APPAREL COLLECTION ERGONOMIC CUTS, OPTIMAL SHOULDER MOBILITY, & PROTECTIVE, HIGH COVERAGE SILLHOUETTES LET ATHLETES FORGET ABOUT THEIR CLOTHING & FOCUS ON PERFORMANCE.

INSPIRED BY RUNNING FOOTWEAR, THE VELOX PUSH GLOVE DESIGN REIMAGINES THE SILHOUETTE OF THE ACCEPTED PUSH GLOVE FORM IN SUCH A WAY THAT IT AFFECTS THE RELEASE OF THE PUSH RIM & ALLOWS THE WRIST TO STAY CLOSER TO A NEUTRAL POSITION—MINIMIZING WRIST OVERUSE INJURY IN THE LONG TERM.

VELOX *PROCESS*

INITIAL SPORT RESEARCH

FIELD RESEARCH & PROBLEM IDENTIFICATION

SKETCH EXPLORATION WITH ATHLETE & EXPERT FEEDBACK

PROTOTYPING, MATERIALS & METHODS EXPLORATION

PRODUCT VALIDATION & WEAR TESTING

MOOD, COLOR, & GRAPHIC IDEATION

FINAL PROTOTYPE CREATION

PHOTOGRAPHY, PACKAGING, & PRODUCT STORY

VELOX *BACKGROUND RESEARCH*

WHEELCHAIR TRACK & MARATHON RACING

THE RACING OF WHEELCHAIRS IN TRACK & FIELD AND ROAD RACES, OPEN TO ATHLETES WITH QUALIFYING DISABILITIES

UNLIKE MARATHON RUNNERS, WHEELCHAIR RACERS WILL OFTEN RACE IN A RANGE OF EVENTS FROM SPRNITS TO DISTANCE

DISABILITY CLASSIFICATIONS

T52: *ATHLETES USE SHOULDER, ARM, & WRIST MUSCLES FOR WHEELCHAIR PROPULSION, POOR TO FULL MUSCLE POWER IN FINGERS, TYPICALLY TRUNK MUSCLE FUNCTION IS ABSENT*

T53: *ATHLETES TYPICALLY HAVE FULL MUSCLE FUNCTION IN THE ARMS, BUT NO ABDOMINAL OR LOWER SPINAL CORD ACTIVITY*

T54: *ATHLETES HAVE FULL MUSCLE FUNCTION IN THE ARMS, SOME TO FULL MUSCLE POWER IN THE TRUNK, AND MAY HAVE SOME MUSCLE FUNCTION IN THE LEGS*

VELOX *ENVIRONMENT TOKYO 2021*

AUG 24-SEPT 5 2021 / 78ºF-95ºF & 73%-75% HUMIDITY / RACERS DO EVERYTHING FROM SPRINTS TO MARATHON / MARATHON HAS INTENSE UPHILL FINISH

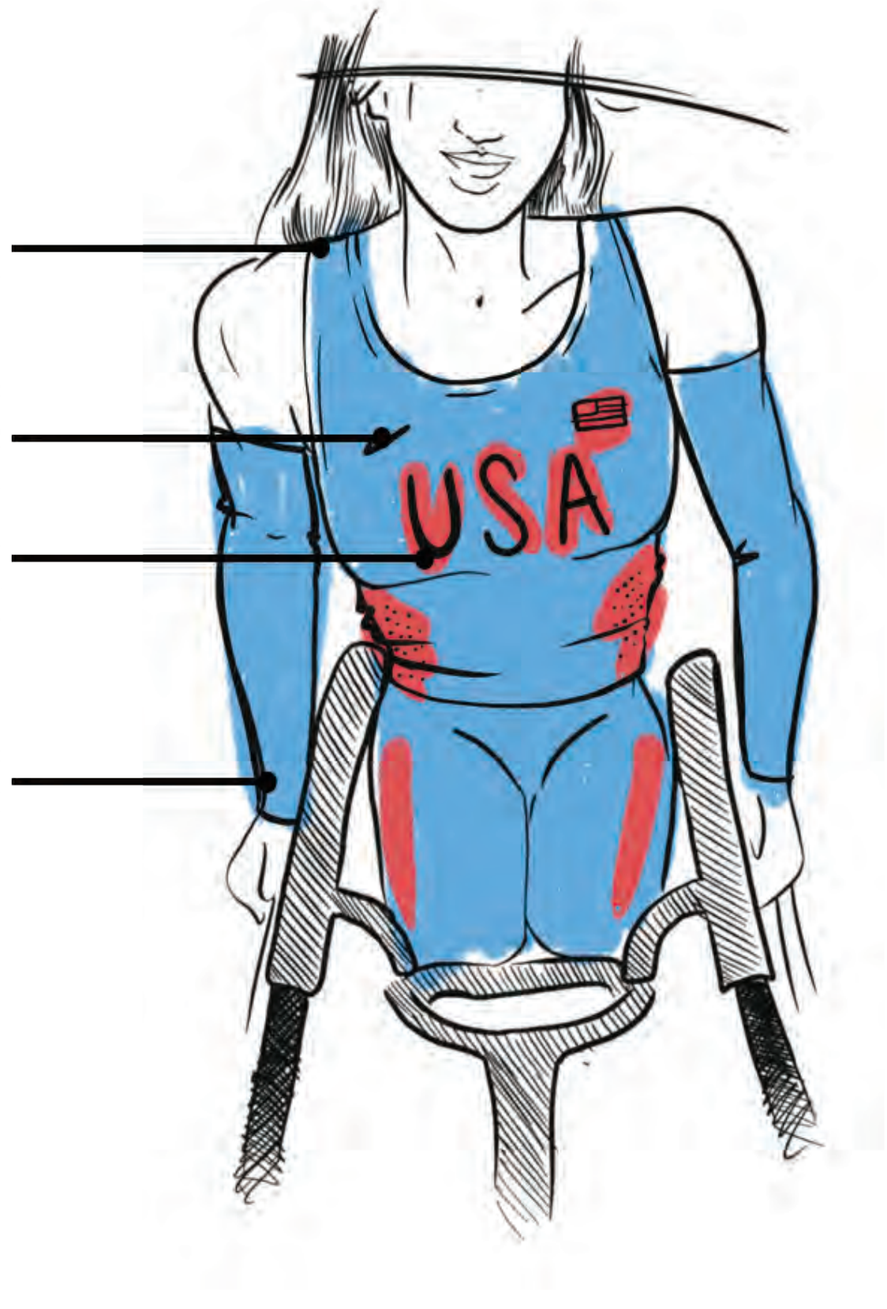
VELOX *UNIFORM RULES & REGULATIONS*

NO COUNTRY NAMES OR MANUFACTURERS LOGOS SHOULD APPEAR ON COLLAR OR NECK

ON UPPER BODY CLOTHING, LOGO OF MANUFACTURER SHOULD BE ON CHEST OR SLEEVE

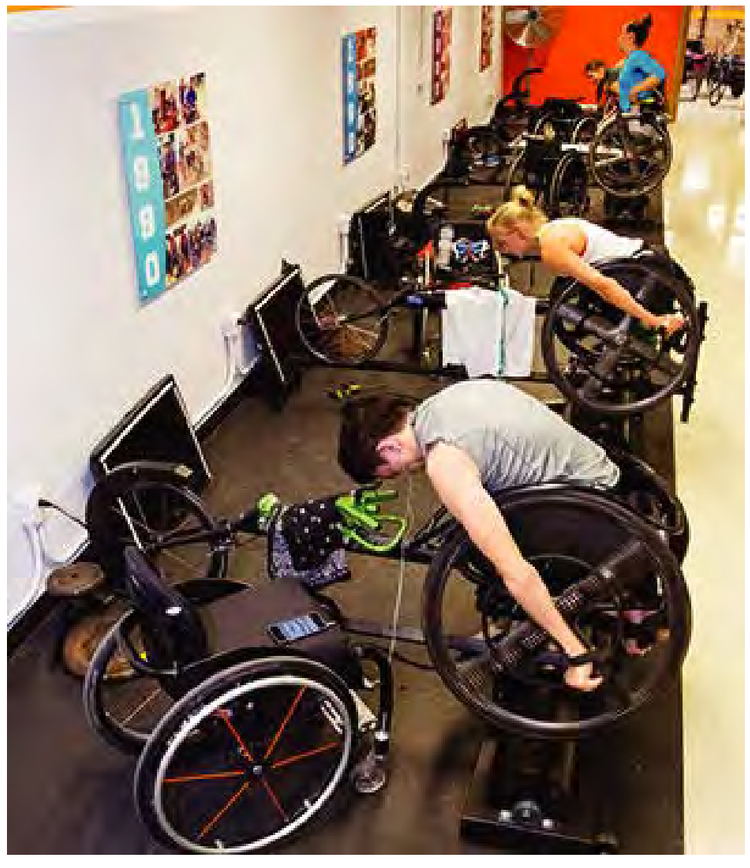
COUNTRIES ARE ENCOURAGED TO USE NATIONAL COLORS, NAMES, & EMBLEMS TO VISUALLY ENHANCE NATIONAL IDENTITY; NO MAXIMUM SIZE OR FREQUENCY IS APPLIED TO NATIONAL EMBLEMS

ARM BANDS MAY HAVE ONE LOGO OF MANUFACTURER, UP TO 6 CM^2 IN SIZE



- MANUFACTURER LOGOS MAY NOT EXCEED 30 CM^2 IN SIZE, ON ELASTIC MATERIALS LOGOS WILL BE MEASURED STRETCHED
- FABRIC MAY NOT BECOME TRANSPARENT WHEN WET
- SINGLETS MUST BE THE SAME COLOR ON THE FRONT & BACK OF THE GARMENT
- ONE LOGO IS PERMITTED ON ZIPPERS & BUTTONS
- FOR SPORTS EQUIPMENT PROVIDED BY ATHLETES, LOGOS MUST BE CONSISTENT WITH PRODUCT SOLD AT RETAIL IN THE 6 MONTHS PRIOR TO THE GAMES
- NO LOGO MAY BE USED IN A CONSPICUOUS WAY FOR ADVERTISING PURPOSES
- NO ITEMS MAY FEATURE LYRICS FROM A NATIONAL ANTHEM, MOTIVATIONAL SLOGANS, OR POLITICAL MESSAGING

VELOX *FIELD RESEARCH: UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN*



OBSERVATION / ATHLETE INTERVIEWS / EXPERT INTERVIEWS / ANTHROPOMETRIC MEASUREMENTS

VELOX *STATE OF THE ART*

"WHEN WE GET TEAM USA GEAR, IT'S JUST GENERIC...SIZING, BUT OBVIOUSLY OUR LOWER BODIES ARE A LOT SMALLER"

- Yen Hoang, 2016 Paralympic Wheelchair Racer

SOME RACERS REQUIRE SLEEVES TO PROTECT FROM CHAFING AGAINST CHAIR

_ FULL LENGTH ARM SLEEVES OR SHIRTS WORN BENEATH SINGLETS BOTH PREVENT EVAPORATIVE COOLING

SCOOP NECKLINES CAN HANG LOOSE WHEN RACERS LEAN FORWARD TO COMPETE

_ ALL RACERS INTERVIEWED PREFERRED HIGH NECKLINES WITH FULL LENGTH FITTED SILHOUETTES

NATIONAL LOGOS AREN'T VISIBLE WHILE COMPETING

_ FOWARD POSITIONING MEANS CHEST LOGOS ARE OUT OF VIEW

UNIFORMS LACK FRONT OF BODY VENTILATION

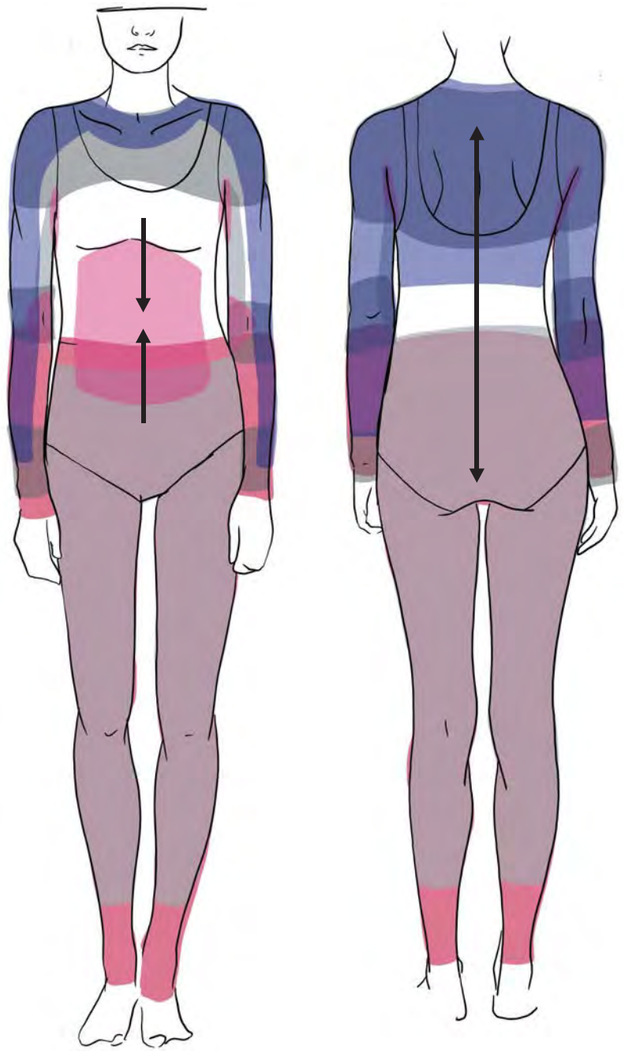
_ MOST SWEAT BUILDUP IS ON THE STOMACH FROM FORWARD POSITIONING

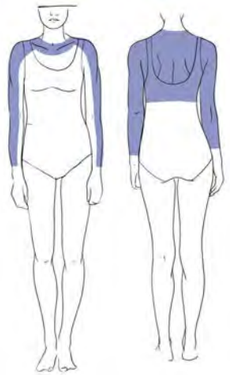
"THE TIGHTS HAD THESE LITTLE RUBBERY THINGS ON THEM. THEY LOOKED COOL BUT WE COULDN'T GET INTO OUR CHAIRS"

- Yen Hoang, 2016 Paralympic Wheelchair Racer

VELOX *APPAREL AREAS OF CONCERN: RACING*

RACING UNIFORM



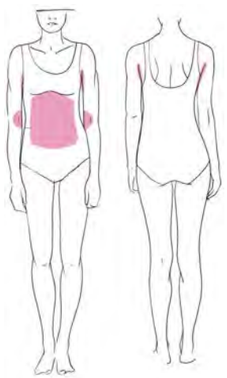


GRAPHIC PLACEMENT

_Traditional center front graphics aren't visible in competition

_Arms aren't utilized as a vehicle for branding

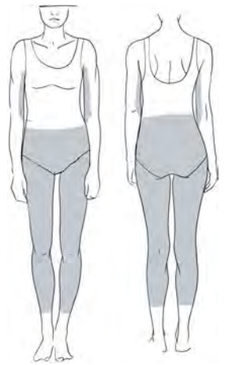
_Consider track curves & camera angles in placement



HEAT & SWEAT MANAGEMENT

_Body positioning causes sweat buildup on the stomach and thighs

_Athletes wear higher coverage clothing for protection, bad for thermoregulation in hot temps

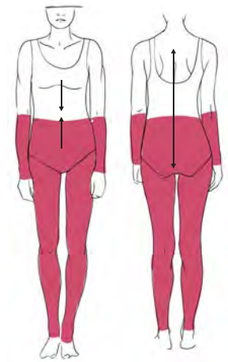


CHAFING & IRRITATION

_Missed strokes & rubbing against fenders causes chafing on inner arms

_Athletes will wear padding or sleeves for protection

_Lower body chafing is dangerous in paraplegic athletes

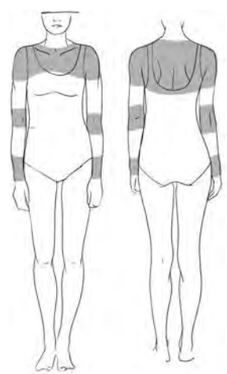


ERGONOMICS & FIT

_Over developed arms & atrophied legs make fit challenging

_Unique working position requires longer back length & shorter front

_Silhouettes need to be fitted to stay out of the chair/straps



MOBILITY

_Complete mobility at shoulders, arms, & wrists is key, opposite of most track events

_No mobility requirements of lower body

VELOX *STATE OF THE ART*

"NOT HAVING IDEAL WATERPROOF GEAR, WE DUCT TAPED TRASH BAGS BENEATH SHIRTS TO KEEP DRY"

- Susannah Scaroni on the Boston Marathon 2018

TRADITIONAL RAIN GEAR LACKS STRETCH REQUIRED FOR PROPER SHOULDER & ELBOW MOBILITY

_ *RUNNING & CYCLING JACKETS ARE PETTERNED FOR THE LIMITED MOBILITY REQUIRED IN THOSE SPORTS*

LAYERING APPAREL CAN IMPEDE SHOULDER & ARM MOBILITY AND ADD BULK

_ *RACERS REQUIRE A TIGHT FIT TO GET INTO CHAIRS & FULL SHOULDER MOBILITY*

LATEX GLOVES ARE WORN FOR WATER PROTECTION & WARMTH

_ *THERMAL GLOVES ARE TOO BULKY TO WEAR WITH THE RIGID PUSH GLOVES*

TYPICAL RAIN JACKETS HAVE USELESS HOODS & FRONT POCKETS

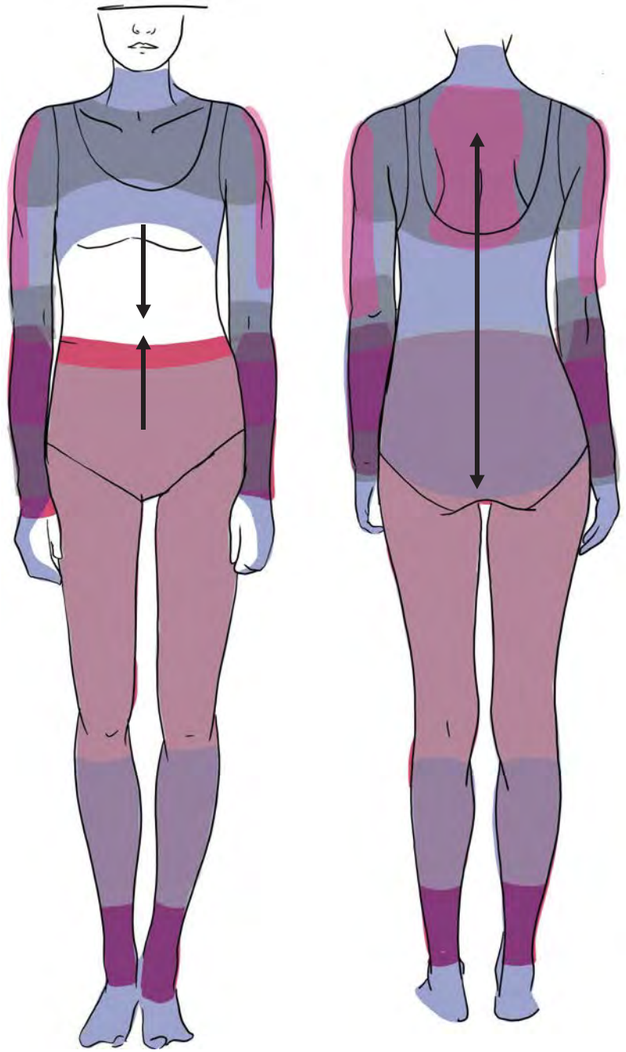
_ *THESE ADD BULK THAT CAN HINDER THE RACER FROM GETTING INTO THE CHAIR & THEY CAN BECOME UNCOMFORTABLE*

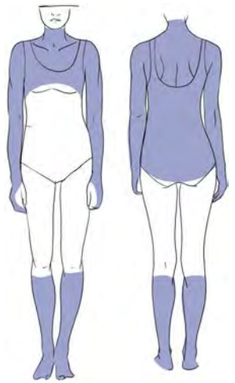
WHEELS SPRAY WATER ONTO LOWER LEGS

_ *LOWER LEG WATER PROTECTION IS REQUIRED*

VELOX *APPAREL AREAS OF CONCERN: TRAINING*

WEATHERPROOF APPAREL



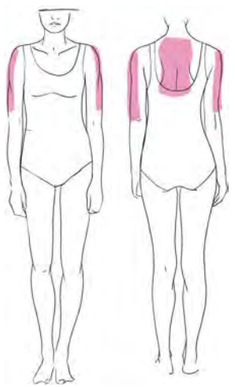


WEATHER PROTECTION

_Difficulty layering apparel with tightness of wheelchair fit

_Lower leg water protection required for spray from chair

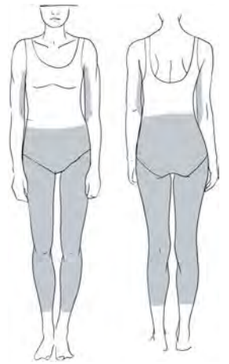
_Full back & arm weather protection required



STORAGE OPPORTUNITIES

_Jackets typically include unuseable front pockets & hoods which add bulk

_lower body front, back, and waistband pockets are unuseable

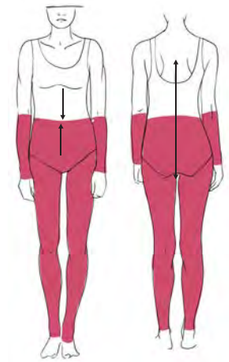


CHAFING & IRRITATION

_Missed strokes & rubbing against fenders causes chafing on inner arms

_Athletes will wear padding or sleeves for protection

_Lower body chafing is dangerous in paraplegic athletes

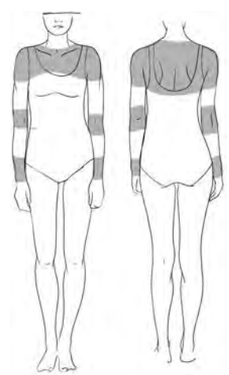


ERGONOMICS & FIT

_Over developed arms & atrophied legs make fit challenging

_Unique working position requires longer back length & shorter front

_Silhouettes need to be fitted to stay out of the chair/straps



MOBILITY

_Layering apparel impedes shoulder & arm mobility

_No mobility requirements of lower body

VELOX *PUSH GLOVE HISTORY*

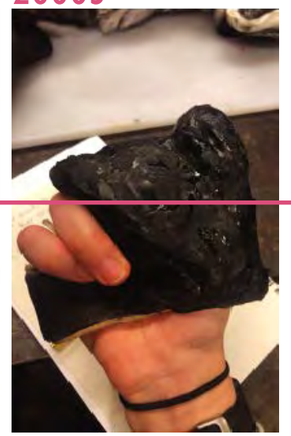
PRE-1990S

_ *HIGHER PROTECTIVE GLOVE, FOAM INHIBITS FORCE TRANSFER, STILL USED TODAY BY BEGINNER RACERS*

EARLY 1990S

EARLY 2000S

2000S



_ *MOVE TO FLAT GLOVES MINIMIZES INJURY*
_ *RIGID GLOVES BETTER FOR FORCE TRANSFER*

EARLY 2010S

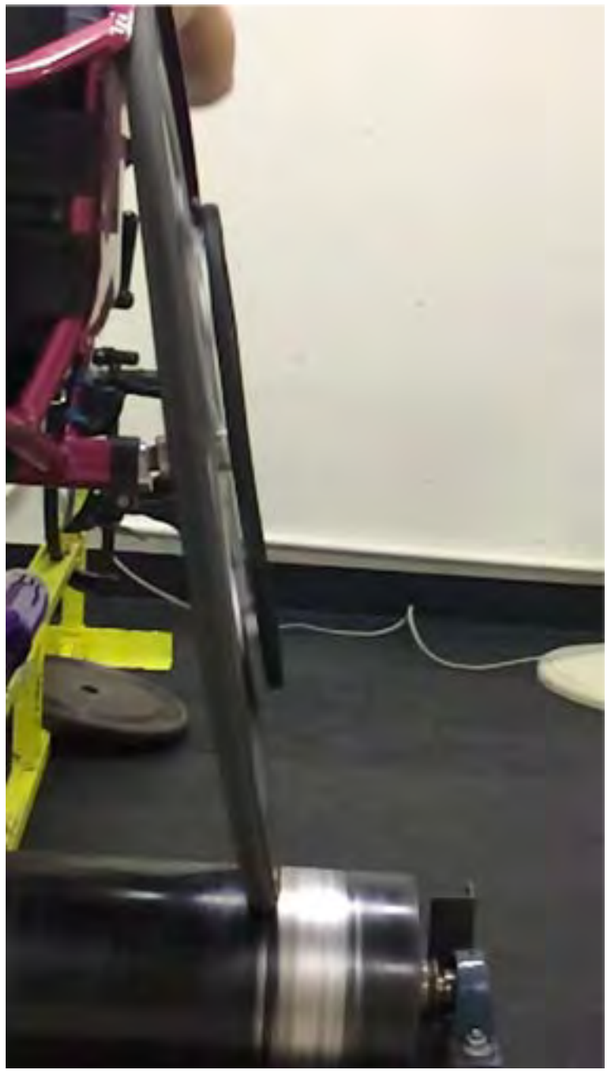
_ *MOVE BACK TO GROOVED STYLE BETTER FOR FORCE TRANSFER & PERFORMANCE*

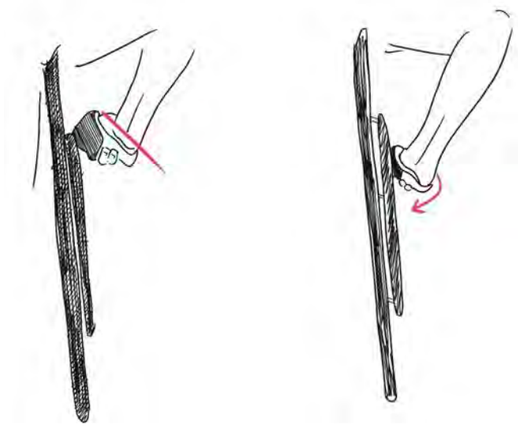
EARLY 2015

CURRENT GLOVES

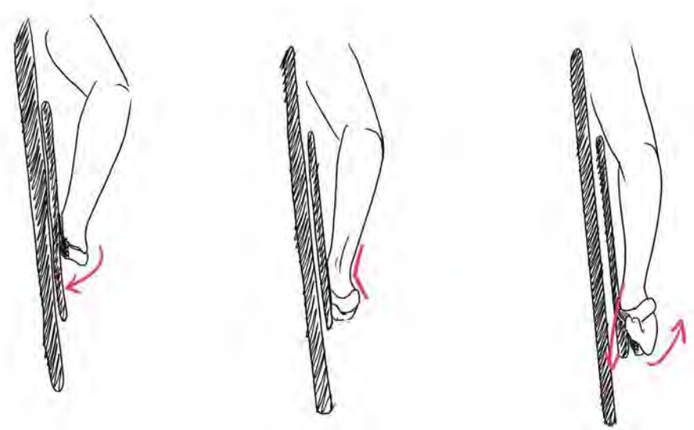
_ *STATE OF THE ART GLOVES ARE 3D PRINTED PLA BASED ON ATHLETE MOLDED GLOVES*
_ *INCLUDES GLUED RUBBER HITTING SURFACE*

VELOX *GLOVE RESEARCH: BIOMECHANICS & INJURY*

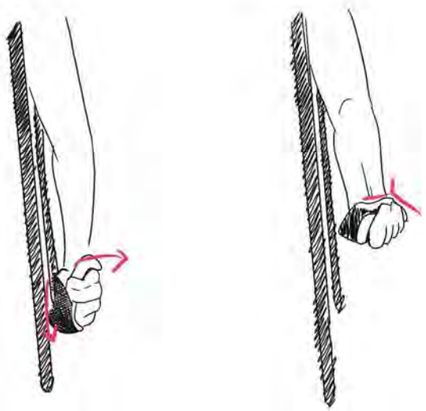




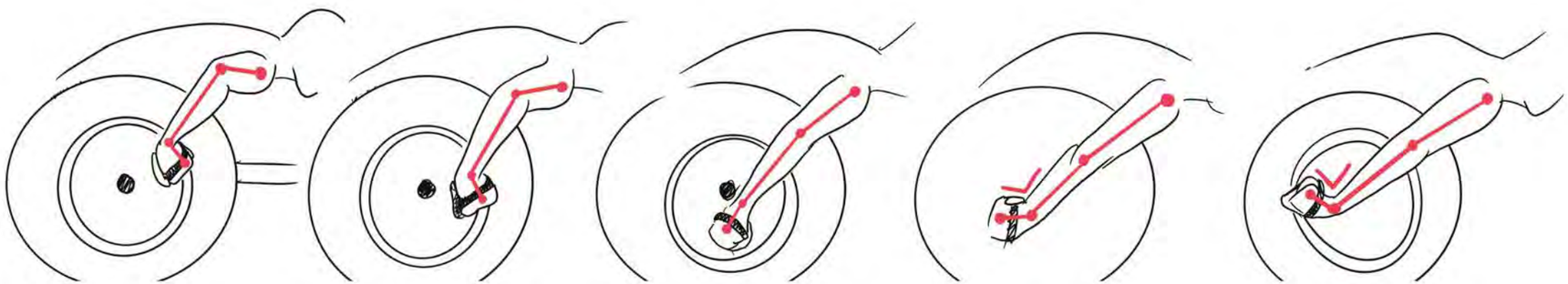
INITIAL COTACT MADE IN GROOVE OF THUMB & FIRST 2 FINGERS, PINKY POINTED OUTWARD



PINKY ROLES INWARD AS HAND DRIVES DOWNWARD. WRIST MOVES INTO NEUTRAL POSITION. CONTACT POINT IS AT BASE OF THUMB.



FOREARM PRONATES INWARD, PINKY ROLES OUT AS THUMB DRIVES DOWN. WRIST IS IN FLEXION WITH PALM FACING UP AT RELEASE



PINKY ROLES INWARD AS HAND DRIVES DOWNWARD. WRIST MOVES FROM RADIAL DEVIATION, TO NEUTRAL POSITIONING, TO ULNAR DEVIATION AT RELEASE.

VELOX *PUSH GLOVE INSPIRATION*

INSPIRED BY RUNNING FOOTWEAR: HOW DO WE PREVENT RUNNING OVERUSE INJURIES?

FOAM CUSHIONING
_ *PROTECTS BODY & JOINTS FROM IMPACT*

ROCKER SHAPES
_ *ALLOWS FOOT TO ROLL SMOOTHLY THROUGH FOOTSTRIKE*

WIDE STABLE BASE
_ *PREVENTS OVER PRONATION, KEEPS FOOT ROLLING SMOOTHLY*

RIGID PLATES
_ *PROVIDES RESPONSIVENESS, STABILIZES FOAM*

TREAD PATTERN
_ *PREVENTS SLIPPAGE AGINST GROUND & UNECESSARY TWISTING MOVEMENTS*

VELOX *RACING UNIFORM*

DESIGNED FOR THE ERGONOMIC, THERMOREGULATIVE, & PROTECTIVE NEEDS OF WOMEN'S WHEELCHAIR RACERS

SUMMER 2021 *TOKYO PARALYMPIC GAMES* *ELITE WOMEN'S WHEELCHAIR RACERS* *FOB $50*

BODY MAPPED VENTILATION
LASER CUT VENTILATION FOCUSED ON THE STOMACH WHERE SWEAT COLLECTS MOST

ERGONOMIC SILHOUETTE
HIGHER RISE & LONGER LENGTH ALONG THE BACK LINE OF THE BODY AND SHORTER IN THE FRONT TO ACCOMODATE THE ATHLETE'S FORWARD LEAN. FITTED TO THE ANTHROPOMETRY OF WHEELCHAIR RACERS

MINIMAL EDGES
LOW PROFILE LASER CUT & GLUED EDGES TO MINIMIZE CHAFING RISK

HIGH COVERAGE & PROTECTIVE DESIGN DETAILS
HIGH NECKLINE, LONG TIGHTS, AND KEVLAR BLENDED ARM SLEEVES TO PROTECT RACERS FROM RACING CHAIR AND KEEP ATHLETE COMFORTABLE

POSITIONING INFORMED GRAPHICS
GRAPHICS VISIBLE BY CAMERA WHILE ATHLETE IS COMPETING, CONCENTRATED ON BACK, UPPER CHEST, & ARMS

VELOX *WEATHERPROOF TRAINING APPAREL*

ERGONOMIC & PERFROMANCE DRIVEN TRAINING APPAREL TO PROTECT RACERS FROM THE ELEMENTS

SUMMER 2021 *TOKYO PARALYMPIC GAMES* *ELITE WOMEN'S WHEELCHAIR RACERS* *FOB $87* *RETAIL PRICE $350*

FITTED & ERGONOMIC SILHOUETTE

FITTED AROUND WAIST & HIP TO FIT INTO CHAIR. LONGER IN BACK AND SHORTER IN FRONT

BODY MAPPED STRETCH PANELS

STRETCH PANELS AROUND CHEST & SHOULDERS TO ALLOW FULL MOBILITY AND A TIGHTER FIT ON THE BODY

GORE TEX™ FABRICS

BREATHABLE WEATHER PROTECTION TO KEEP ATHLETE DRY & COMFORTABLE

CONSIDERED STORAGE & MINIMAL DESIGN

NO FRONT POCKETS OR HOODS THAT COULD GET IN ATHLETES WAY. CONSIDERED POCKETS TO ALLOW FOR STORAGE OF CARDS & KEYS THAT WON'T IMPEDE MOTIONS

POSITIONING INFORMED GRAPHICS

GRAPHICS VISIBLE WHILE ATHLETE IS IN ACTION, FOCUSED ON ARMS

VELOX *PUSH GLOVE*

PUSH GLOVES DESIGNED TO PROTECT THE HAND & MINIMIZE WRIST STRAIN WITHOUT IMPACTING PERFORMANCE

SUMMER 2021 *TOKYO PARALYMPIC GAMES* *ELITE WOMEN'S WHEELCHAIR RACERS* *FOB $75* *RETAIL PRICE $300*

FOAM PROTECTED HITTING SURFACE
MINIMIZE IMPACT INJURY AND ALLOW FOR A MORE SECURE GRIP ON THE PUSH RIM

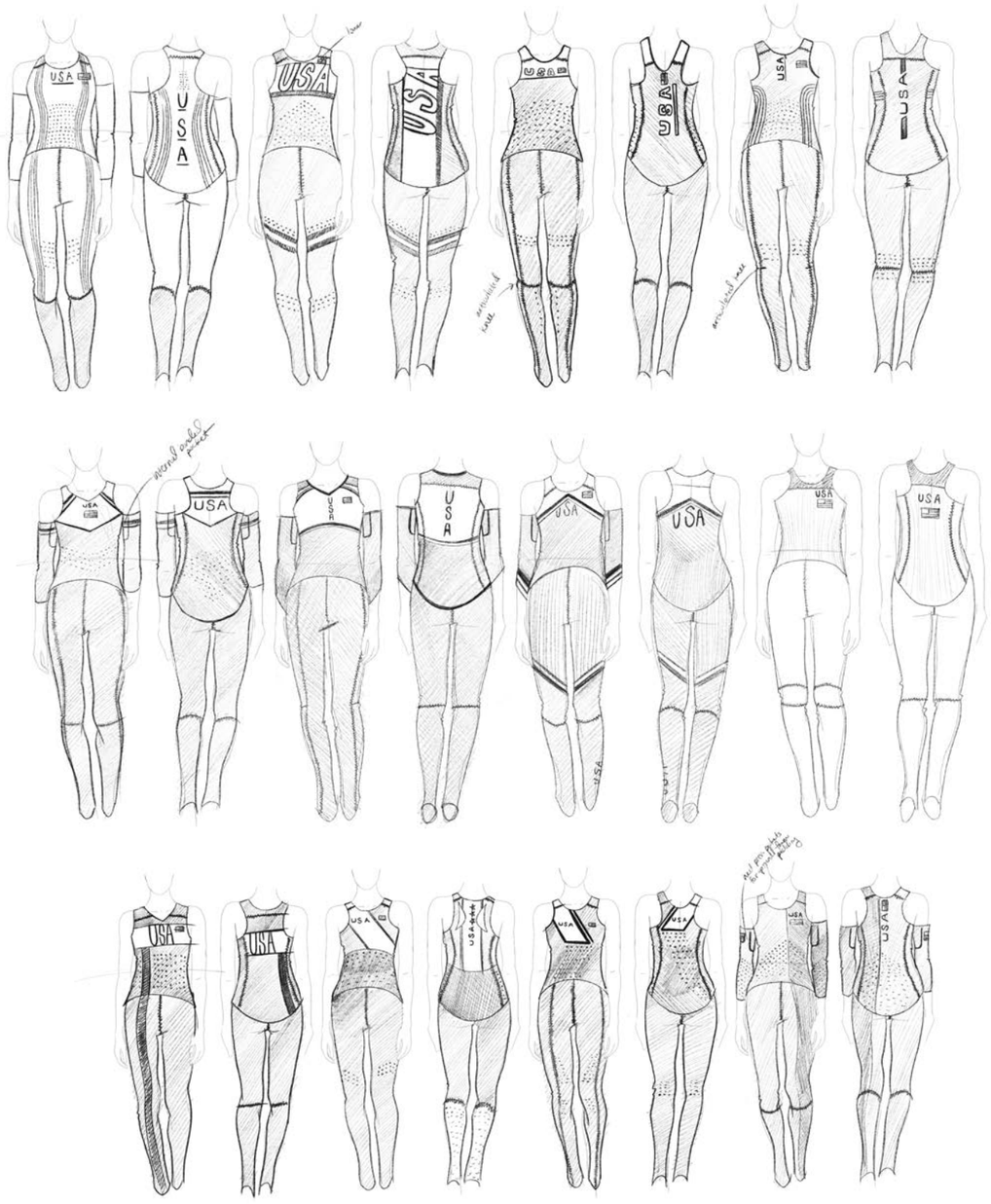
TREAD PATTERN ENHANCED RUBBER
ENHANCE TRACTION IN HUMID CONDITIONS & LEND A PERFORMANCE AESTHETIC

SLEEK & FLUID GEOMETRY
PROVIDE A PERFORMANCE AESTHETIC TO THE PIECE & ELEVATE THE PERCIEVED INTEGRITY OF THE GLOVE

FLARED THUMB SHAPE
LESSEN FOREARM PRONATION AT THE BACK OF THE RACING STROKE TO MINIMIZE ULNAR DEVIATION, KEEP THE WRIST CLOSER TO NEUTRAL POSITIONING, AND MINIMIZE INJURY RISK OVER TIME

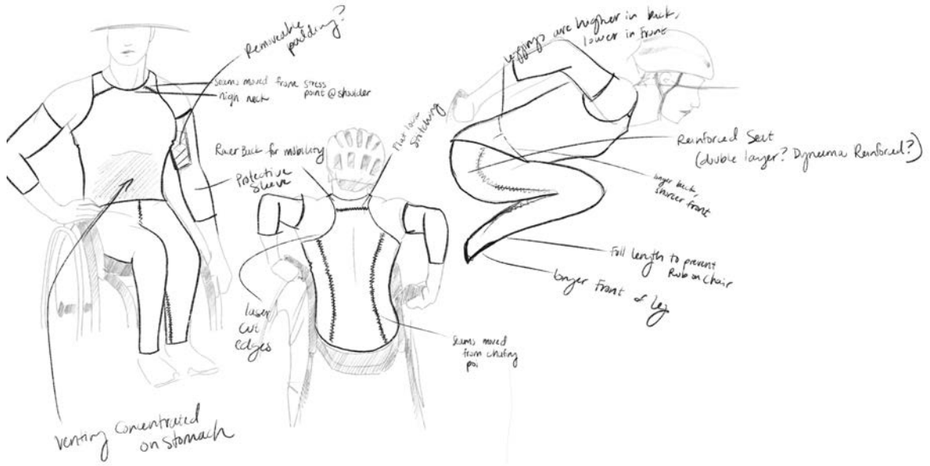
METALLIC FINISHES
FLICKER IN SUNLIGHT & STADIUM LIGHTING TO PROVIDE VISUAL INTEREST AS THE ATHLETE MOVES

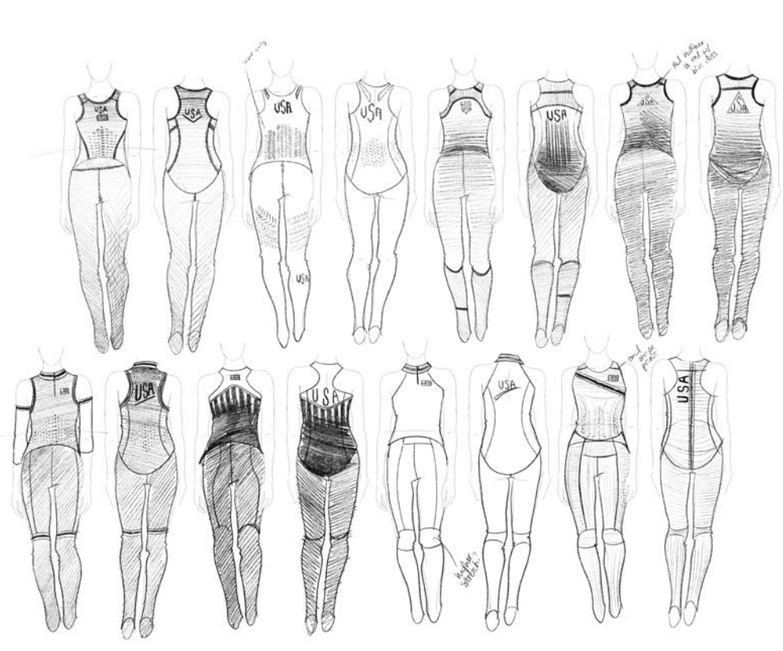
VELOX *UNIFORM SKETCHES*



SILHOUETTE / GRAPHIC PLACEMENT EXPLORATION / ATHLETE PERCEPTION

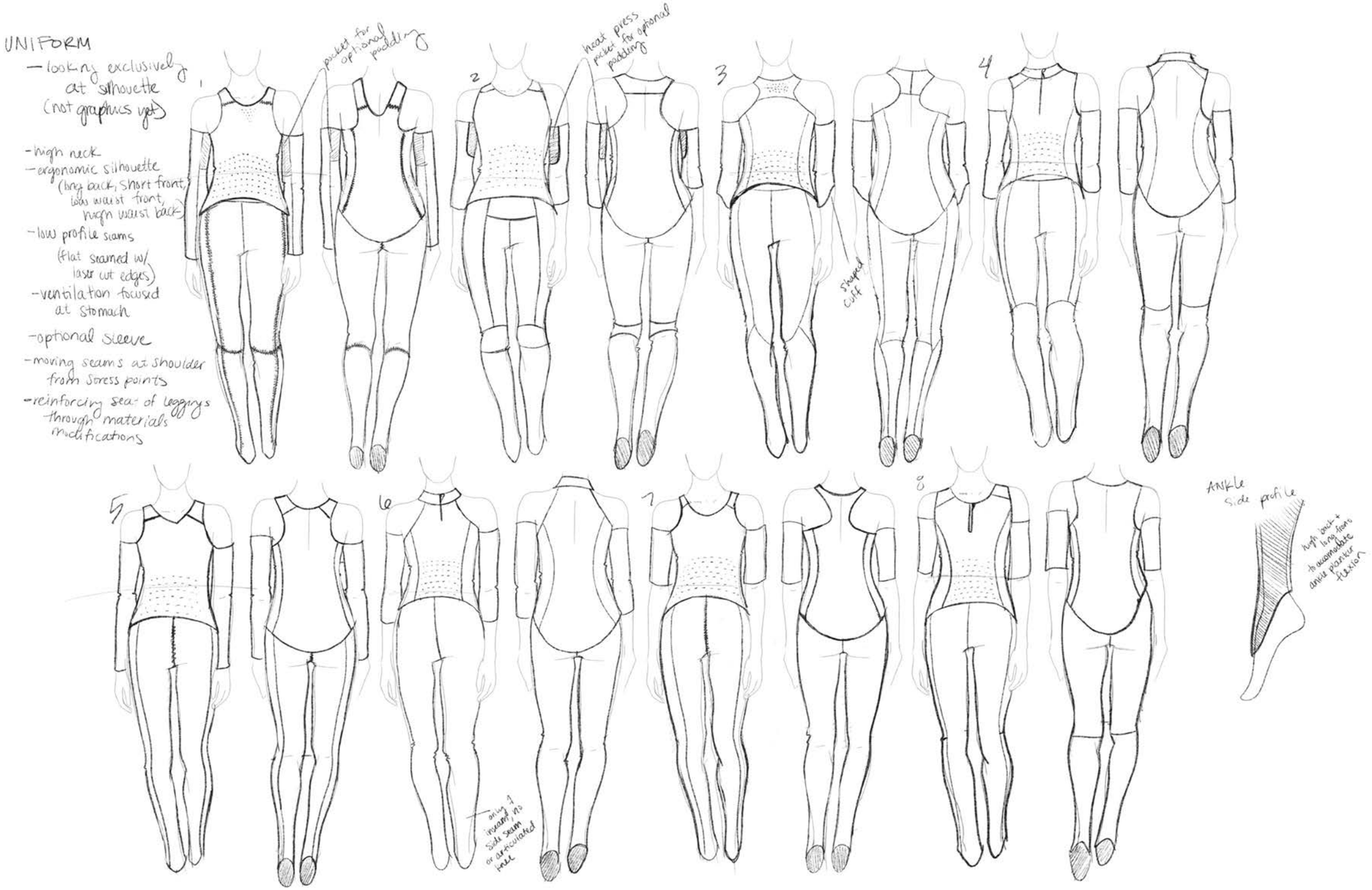
VELOX *UNIFORM SKETCHES*





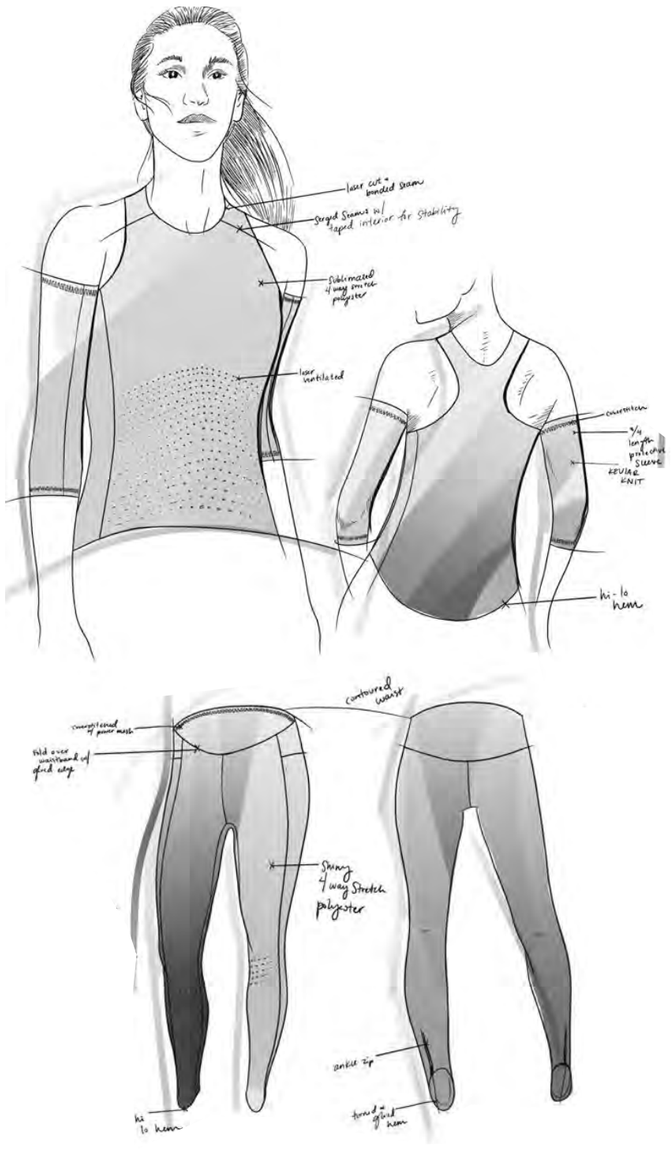
SILHOUETTE / GRAPHIC PLACEMENT EXPLORATION / ATHLETE PERCEPTION

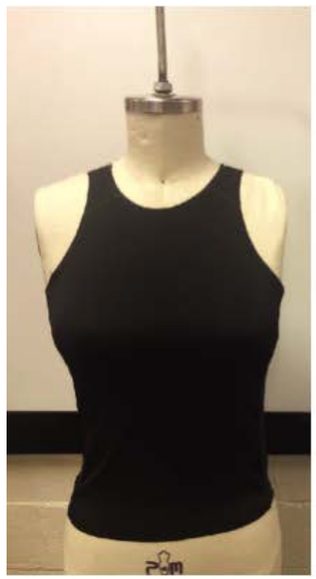
VELOX *UNIFORM SKETCHES*

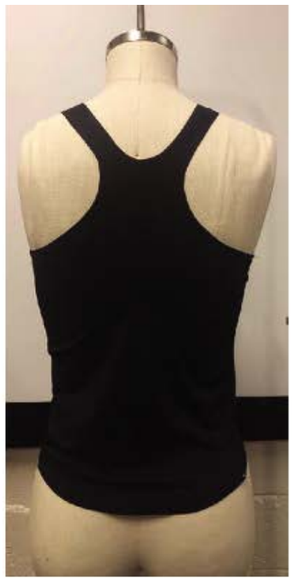


SILHOUETTE / GRAPHIC PLACEMENT EXPLORATION / ATHLETE PERCEPTION

VELOX *UNIFORM PROTOTYPING*







FITTING / PATTERN & FINISH EXPERIMENTATION / PROOF OF CONCEPT & WEAR TEST

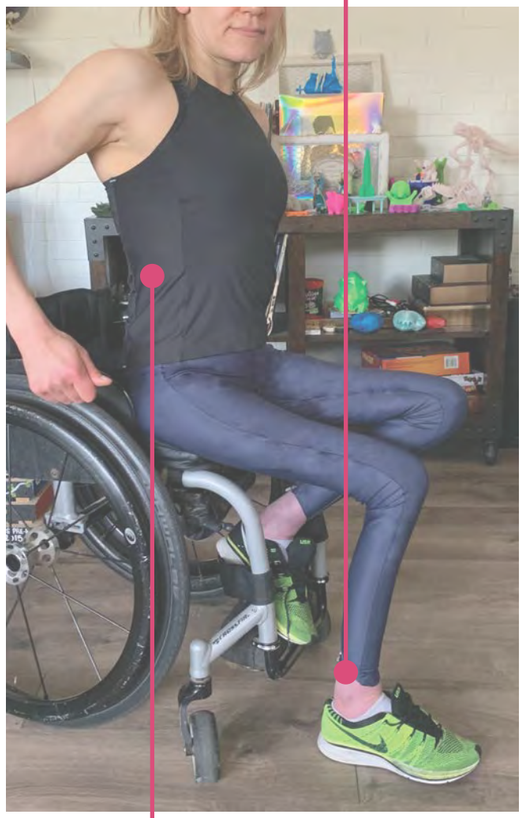
VELOX *VALIDATION: UNIFORM*

FITTING PERCEPTION

Susannah Scaroni, US Wheelchair Racing Paralympic Athlete

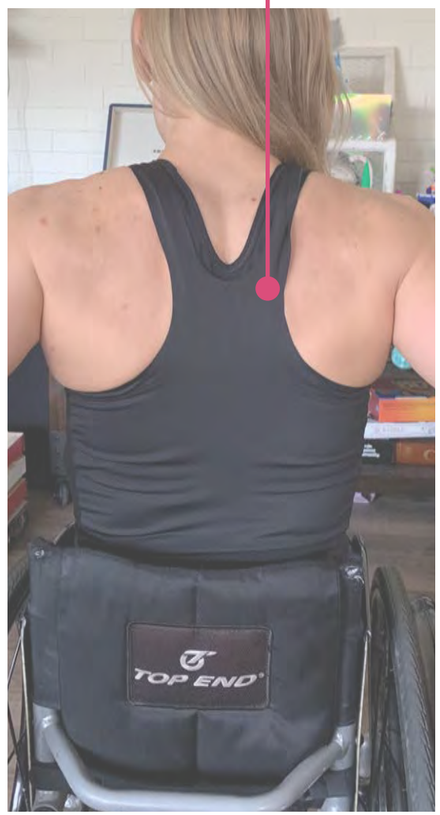
"I REALLY LIKE THE HIGH NECK, AND THE FABRIC IS NICE & LIGHT"

"THE LEGGINGS COME UP TO A GOOD POINT ON THE WAIST, UP BELOW MY RIBS, & I LOVE THE SLIPPERY FABRIC!"

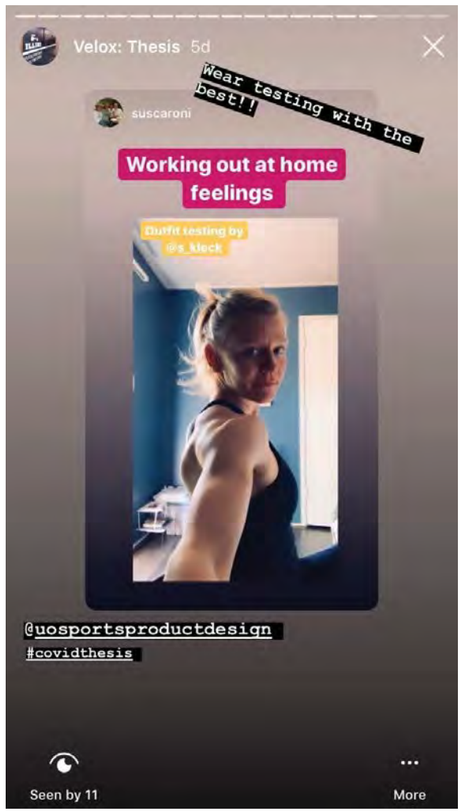


"THE TOP FITS WELL, TIGHT BUT NOT TOO TIGHT. IT'S LOOSE ENOUGH TO BE COMFORTABLE, BUT NOT SO MUCH THAT THERE'S EXTRA FABRC BUNCHED UP IN THE FRONT"

"I LIKE HOW THE ANKLE ZIP LETS THE HEM STAY REALLY TIGHT"



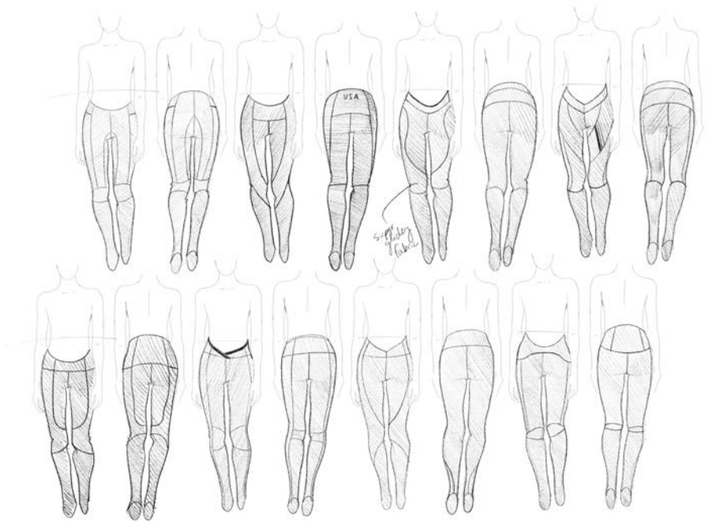
"REALLY LOVE RACERBACK TANKS"

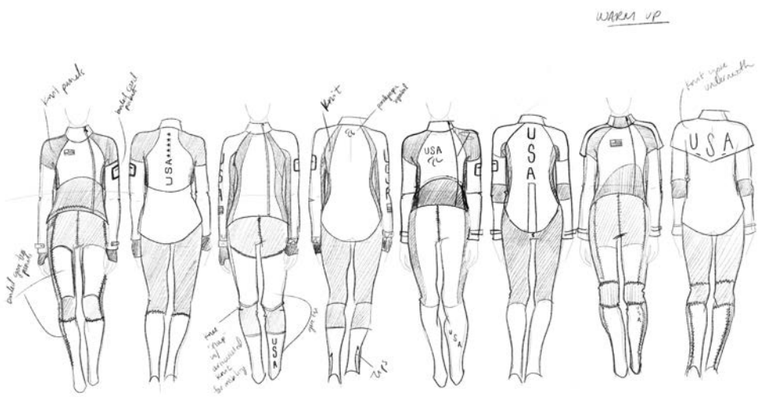


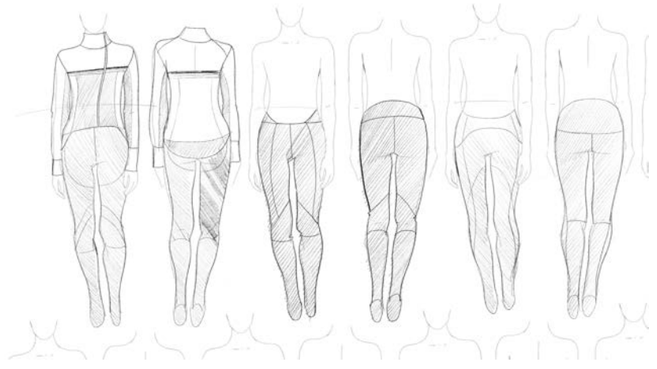
WEAR TEST

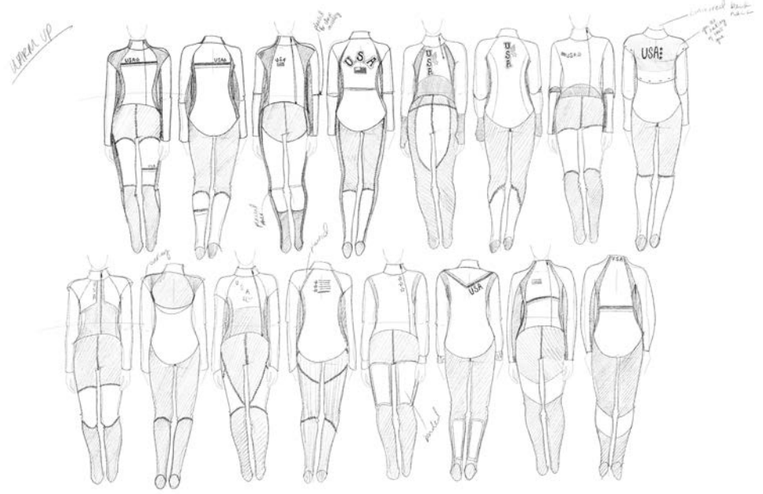
"THEY'RE ALL REALLY AWESOME, AS WELL AS DIFFERENT FROM MY OTHER CURRENT OPINIONS. REALLY GRATEFUL FOR YOUR UNDERSTANDING OUR UNIQUE NEEDS."

VELOX *TRAINING SKETCHES*



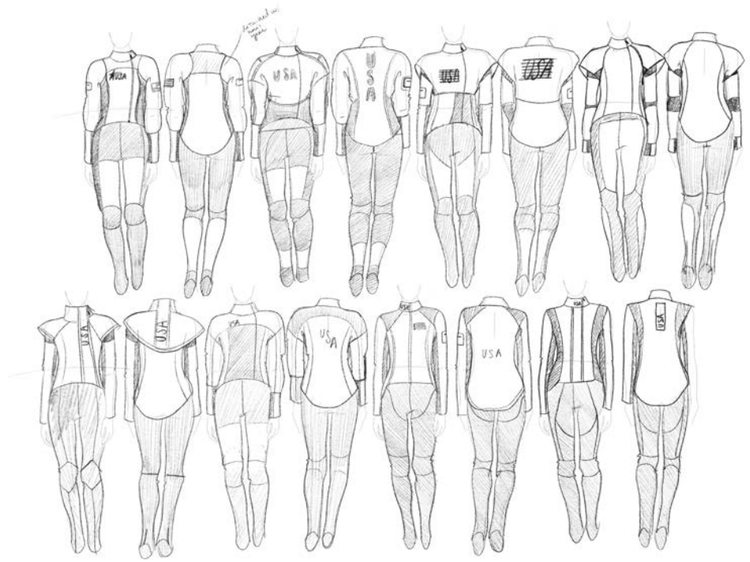


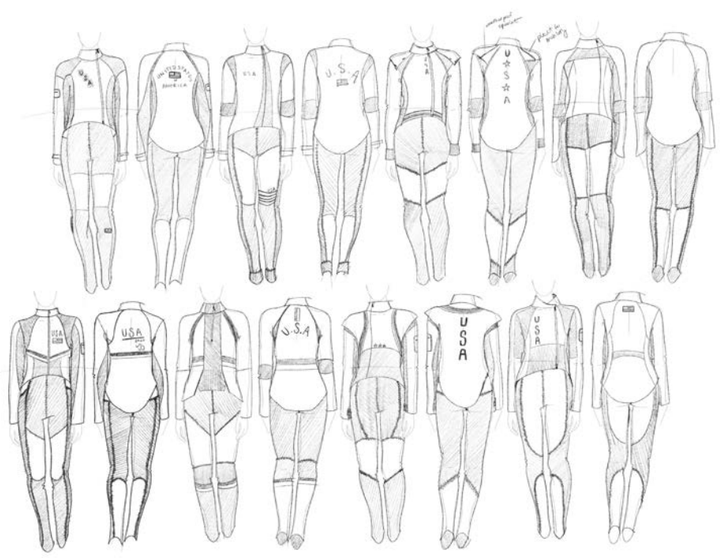


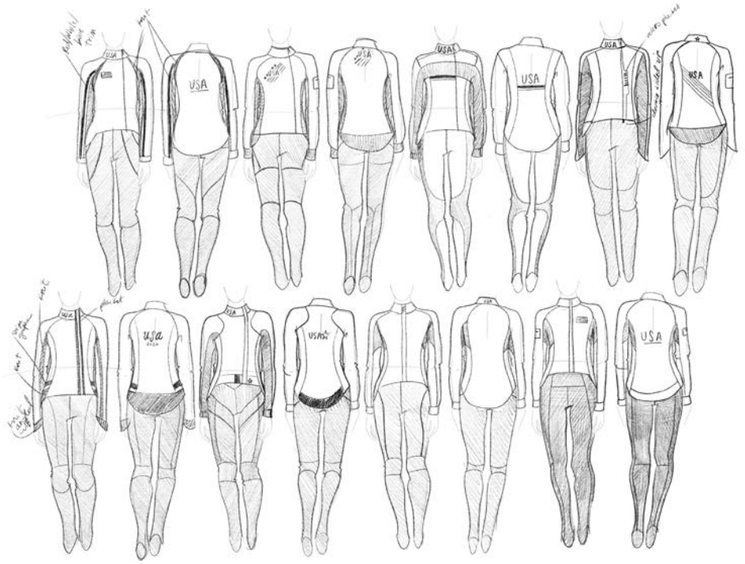


SILHOUETTE / STRETCH PANEL SHAPE & PLACEMENT / WATERPROOF PANELING SHAPE & PLACEMENT

VELOX *TRAINING SKETCHES*

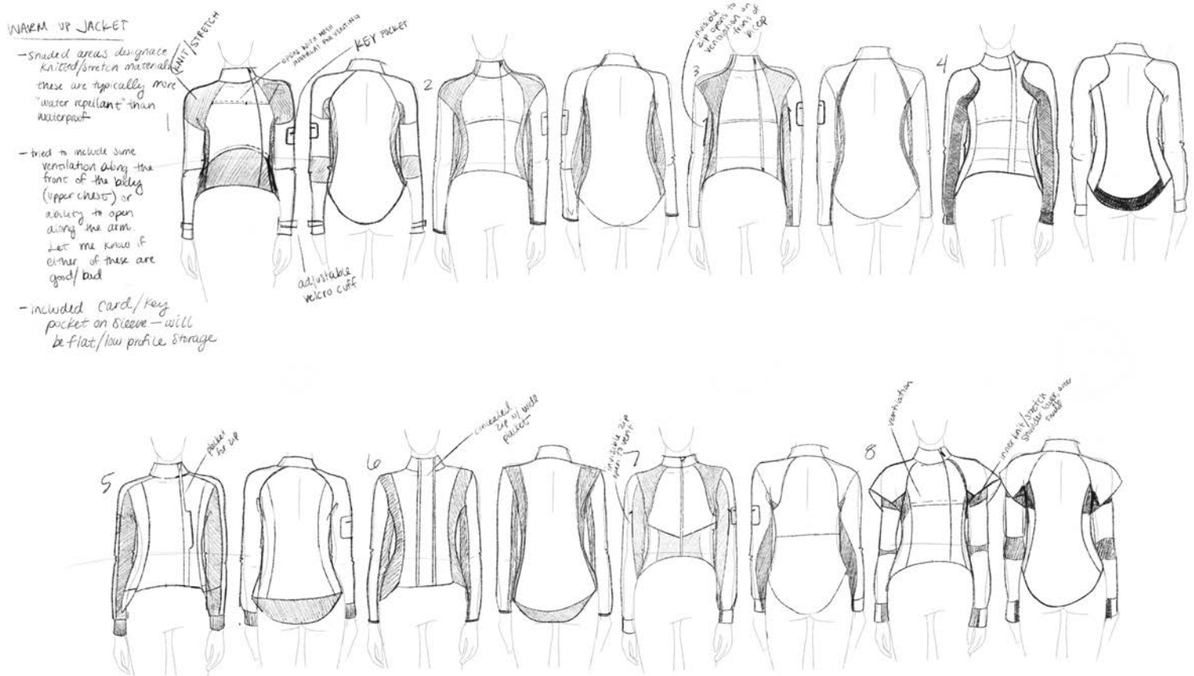


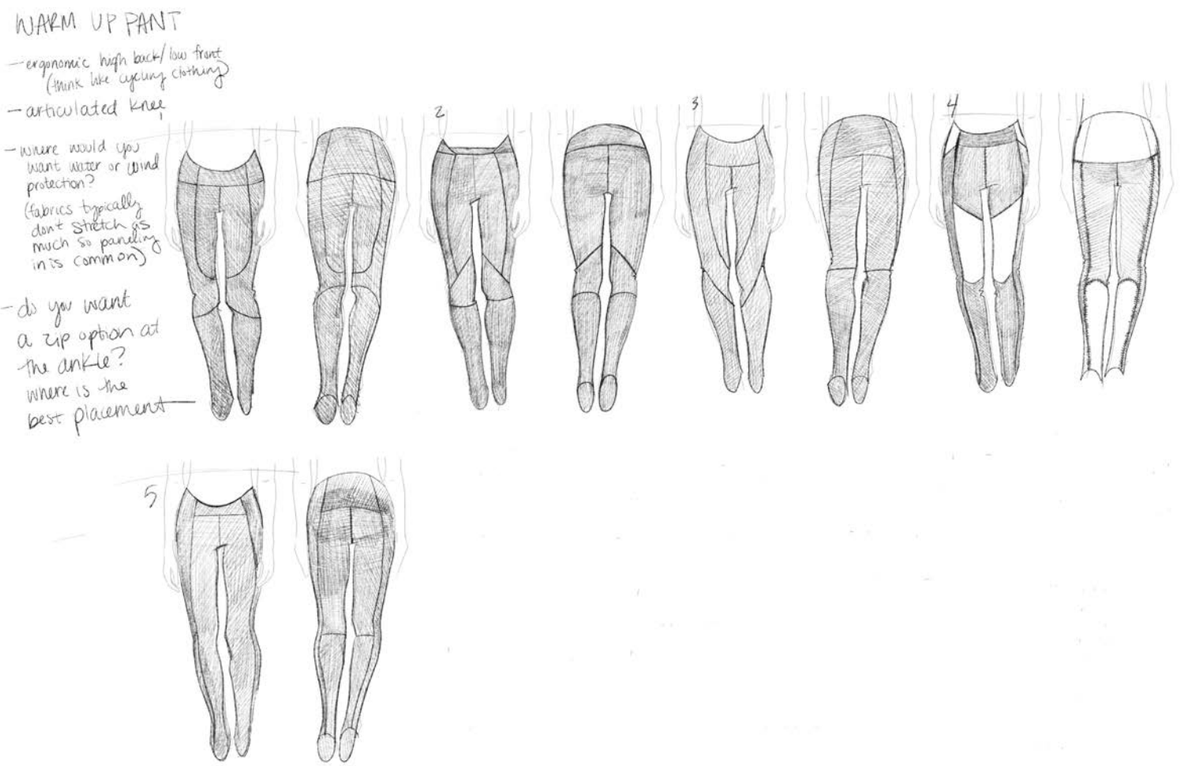




SILHOUETTE / STRETCH PANEL SHAPE & PLACEMENT / WATERPROOF PANELING SHAPE & PLACEMENT

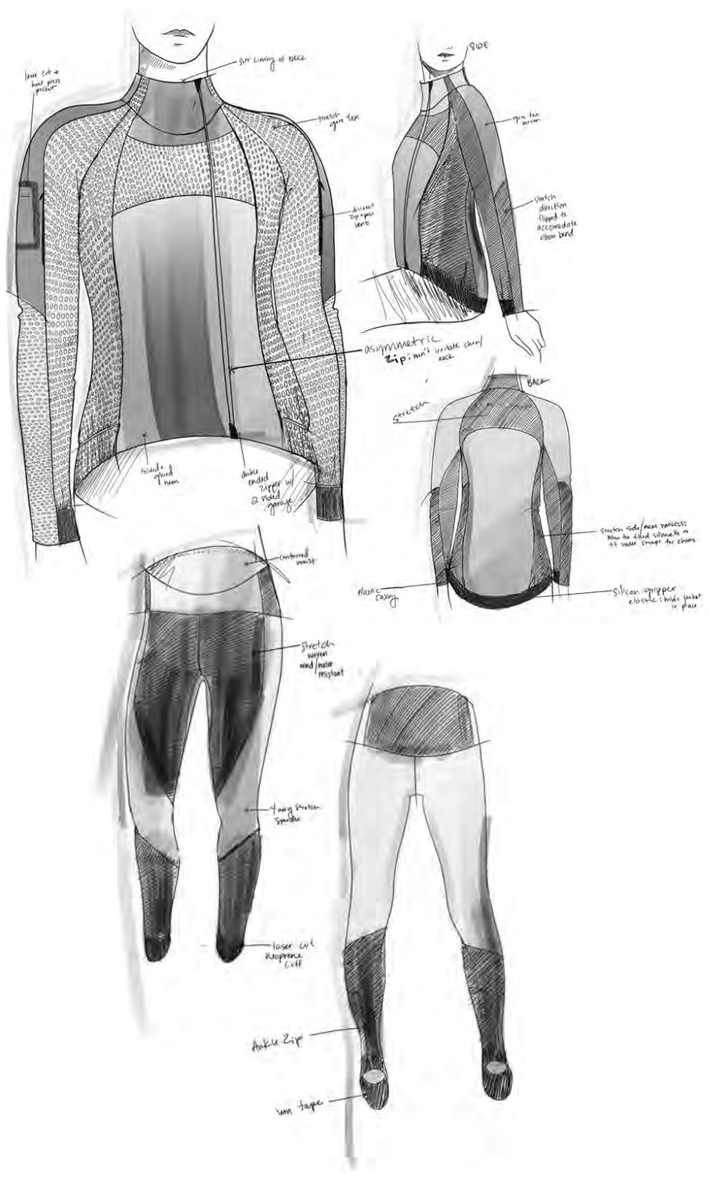
VELOX *TRAINING SKETCHES*





SILHOUETTE / STRETCH PANEL SHAPE & PLACEMENT / WATERPROOF PANELING SHAPE & PLACEMENT

VELOX *TRAINING PROTOTYPES*

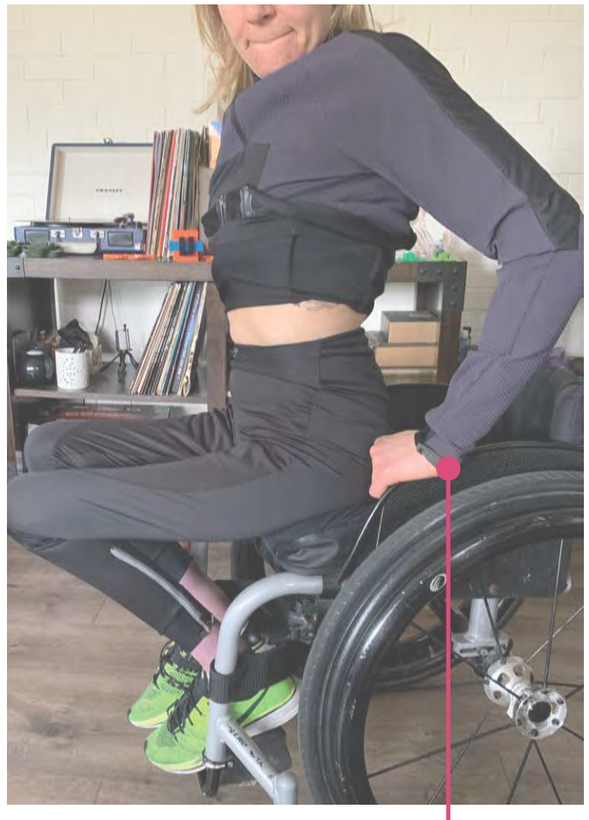


FITTING / PATTERN EXPERIMENTATION / PROOF OF CONCEPT & WEAR TEST

VELOX *VALIDATION: TRAINING APPAREL*

FITTING PERCEPTION

Susannah Scaroni, US Wheelchair Racing Paralympic Athlete



"THE CUFF STAYS REALLY NICE AND TIGHT AGAINST THE WRIST"

"THE LONGER LENGTH IN THE BACK COVERS MY BACK WHEN I LEAN FORWARD, BUT IT DOESN'T BUNCH UP IN THE FRONT"

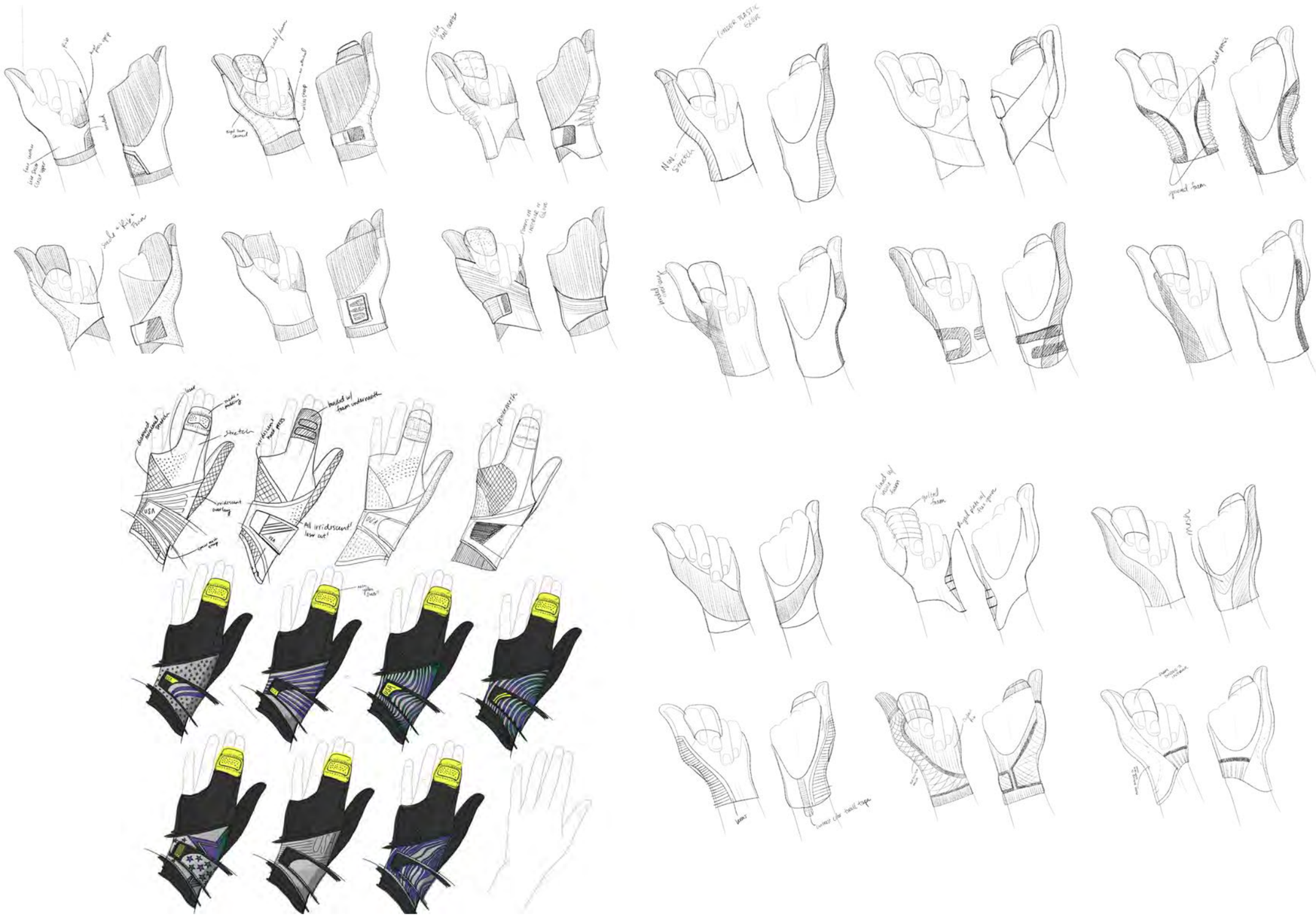
"I LIKE THE HIGH COLLAR & THE FULL ZIP SO I CAN TAKE IT OFF WITHOUT REMOVING MY HELMET"

"THE LEGGINGS ARE A BIT SHORT, BUT I'D BE WEARING LONG SOCKS WITH THEM"

WEAR TEST

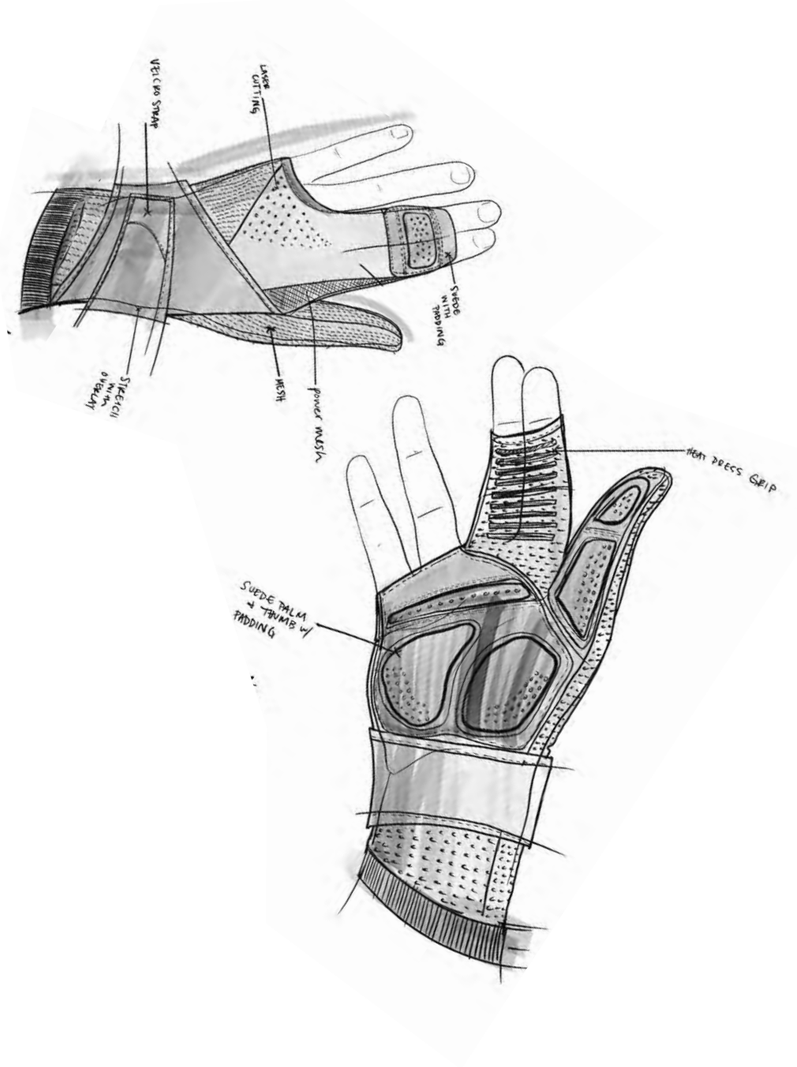
"THE JACKET PROVIDED REALLY NICE COVERAGE, BUT WASN'T BULKY. IT HONESTLY DID GIVE FULL MOBILITY FOR THE WORKOUT."

VELOX *SOFT GLOVE SKETCHES*



SUPPORT / COMFORT

VELOX *SOFT GLOVE PROTOTYPING*



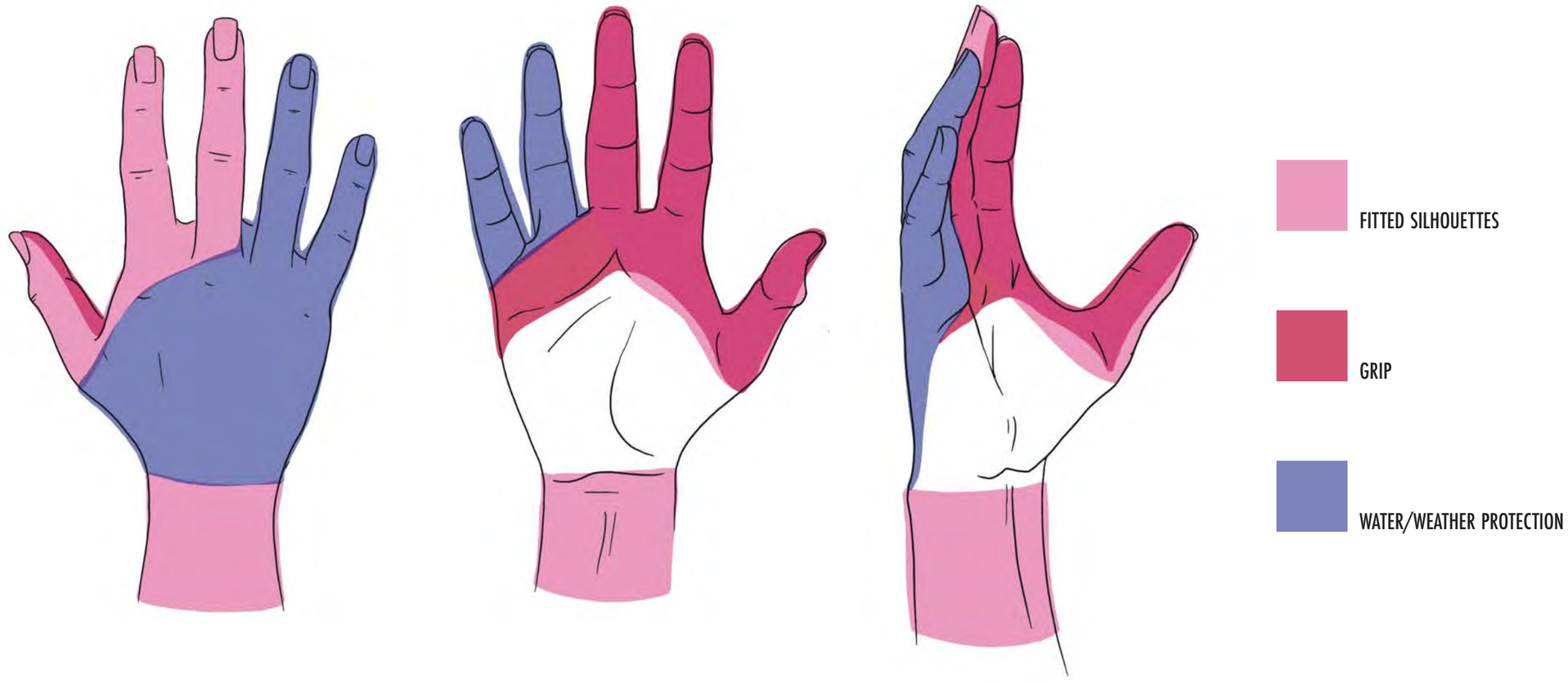
ATHLETE PERCEPTION FEEDBACK

"IT FEELS LIKE IT MIGHT BE TOO RESTRICTIVE, YOU NEED SOME OF THAT WRIST MOVEMENT FOR PERFORMANCE REASONS.

IF IT COVERED THE OTHER TWO FINGERS AND NOT THESE [THUMB, POINTER, MIDDLE] IT'D BE USEFUL FOR WINTER TRAINING BECAUSE YOUR FINGERS GET COLD! THE ONES THAT ARE COVERED ARE FINE, BUT THESE ONES ARE EXPOSED. WE'LL WEAR LATEX GLOVES SOMETIMES BECAUSE IT'S ALL THAT FITS IN THE PUSH GLOVE."

-Arielle Rausin, US PARALYMPIC WHEELCHAIR RACING ATHLETE, CEO OF INGENIUM MANUFACTURING

VELOX *WEATHER MIT HAND MAPPING*



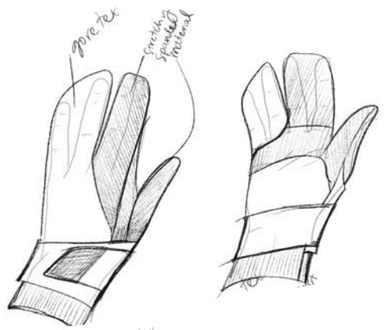
FITTED SILHOUETTES

GRIP

WATER/WEATHER PROTECTION

VELOX *WEATHER MIT PROTOTYPING*

1



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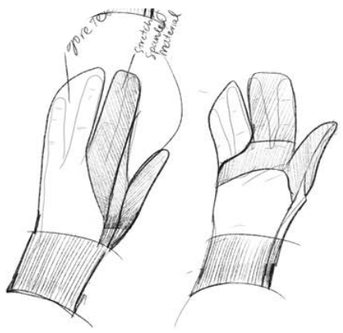

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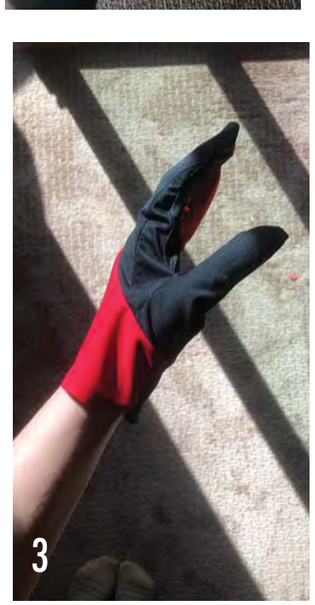
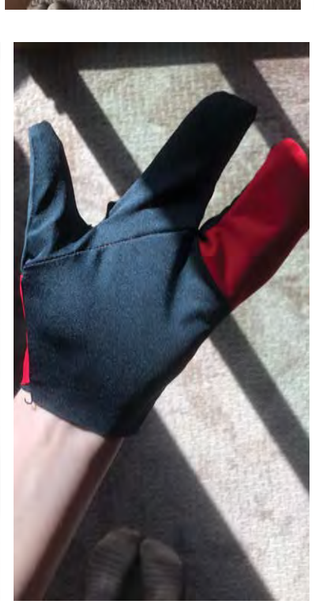




FITTING / PATTERN & MATERIALS EXPERIMENTATION / PROOF OF CONCEPT

VELOX *VAIDATION: WEATHER MIT*

SKETCH FEEDBACK

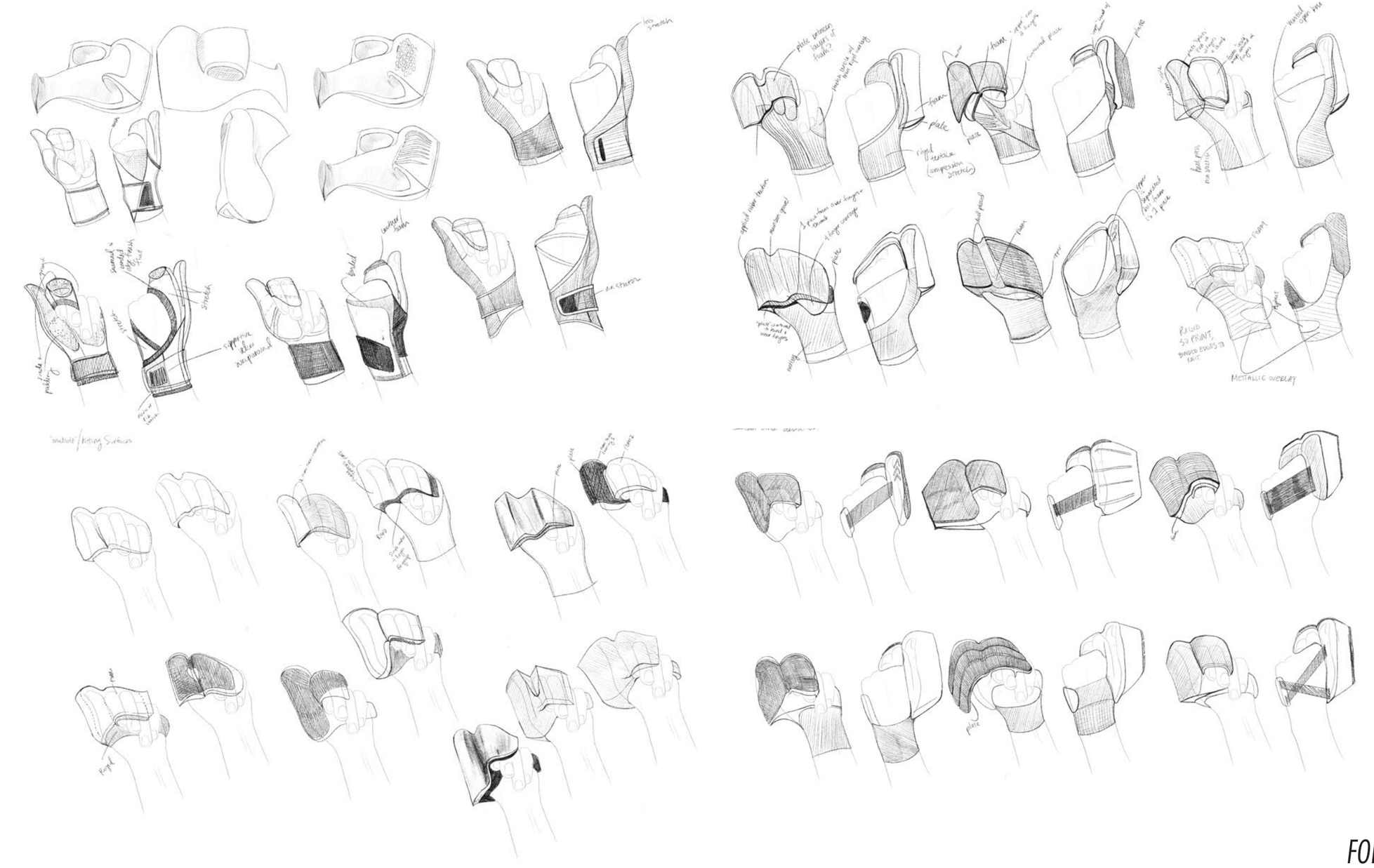
Susannah Scaroni & Arielle Rausin, US Wheelchair Racing Paralympic Athletes

"I LIKE THE IDEA OF THE WRIST CUFF WITH JUST ELASTIC AND NO STRAP. I THINK I FLEX MY WRIST BACK SO MUCH WHEN I'M PUSHING UPHILL THAT I WOULD MISS THAT FLEXIBILITY IF I HAD A STRAP TO NEUTRALIZE THAT MOVEMENT."

"I THINK A THIN SPANDEX-Y FABRIC ON THE GLOVE GRIPPING FINGERS WOULD BE GREAT! SPANDEX SEEMS THIN ENOUGH TO FIT INSIDE THE GLOVE AND SOUNDS MORE COMFORTABLE THAN OTHERWISE FULL EXPOSURE"

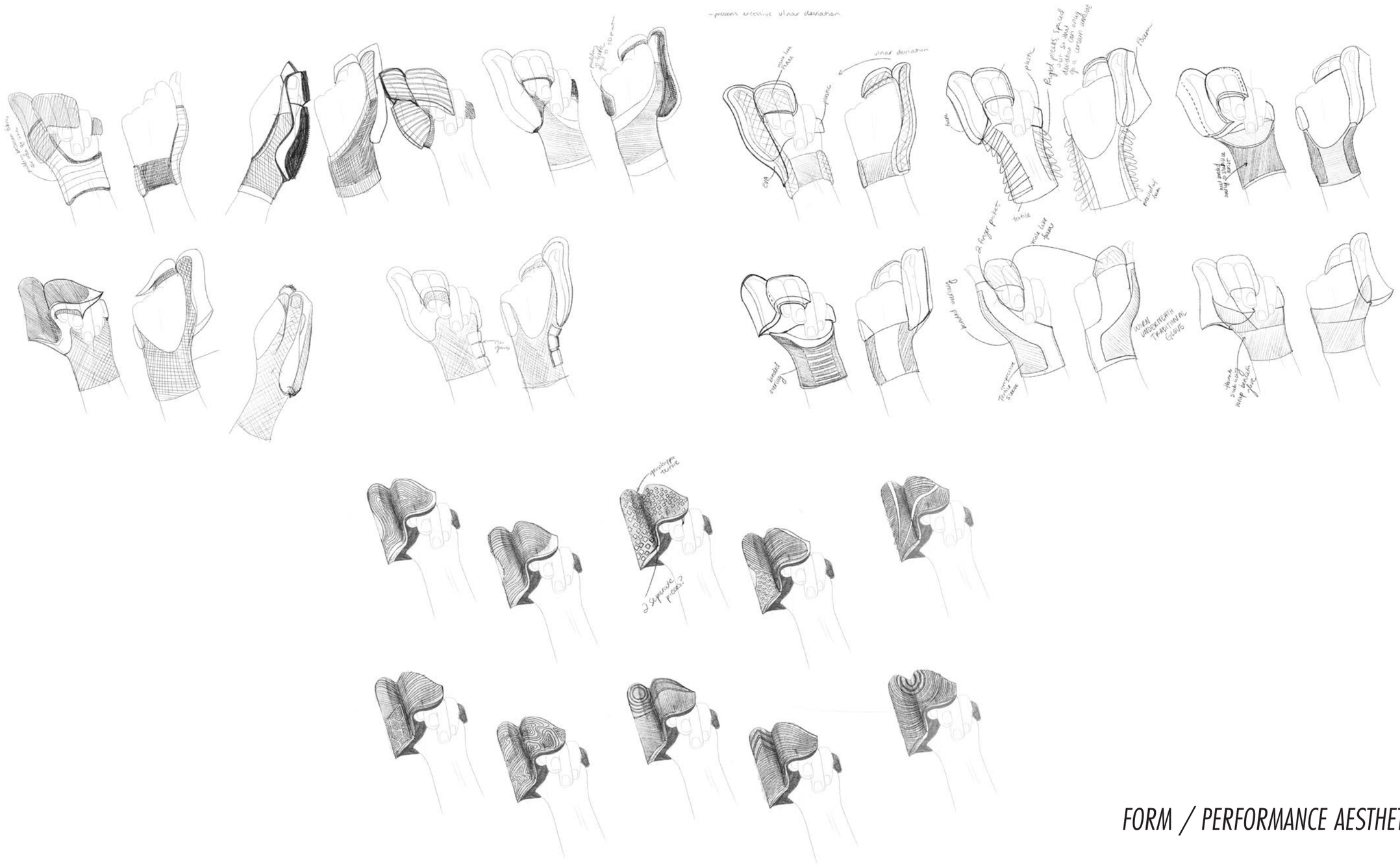
"I LOVE THE IDEA OF GRIP ON THE PALM! A LITTLE GRIP ON THE INSIDE OF THE PALM SOUNDS NICE, ESPECIALLY IN WET AND COLD CONDITIONS."

VELOX *PUSH GLOVE SKETCHES*



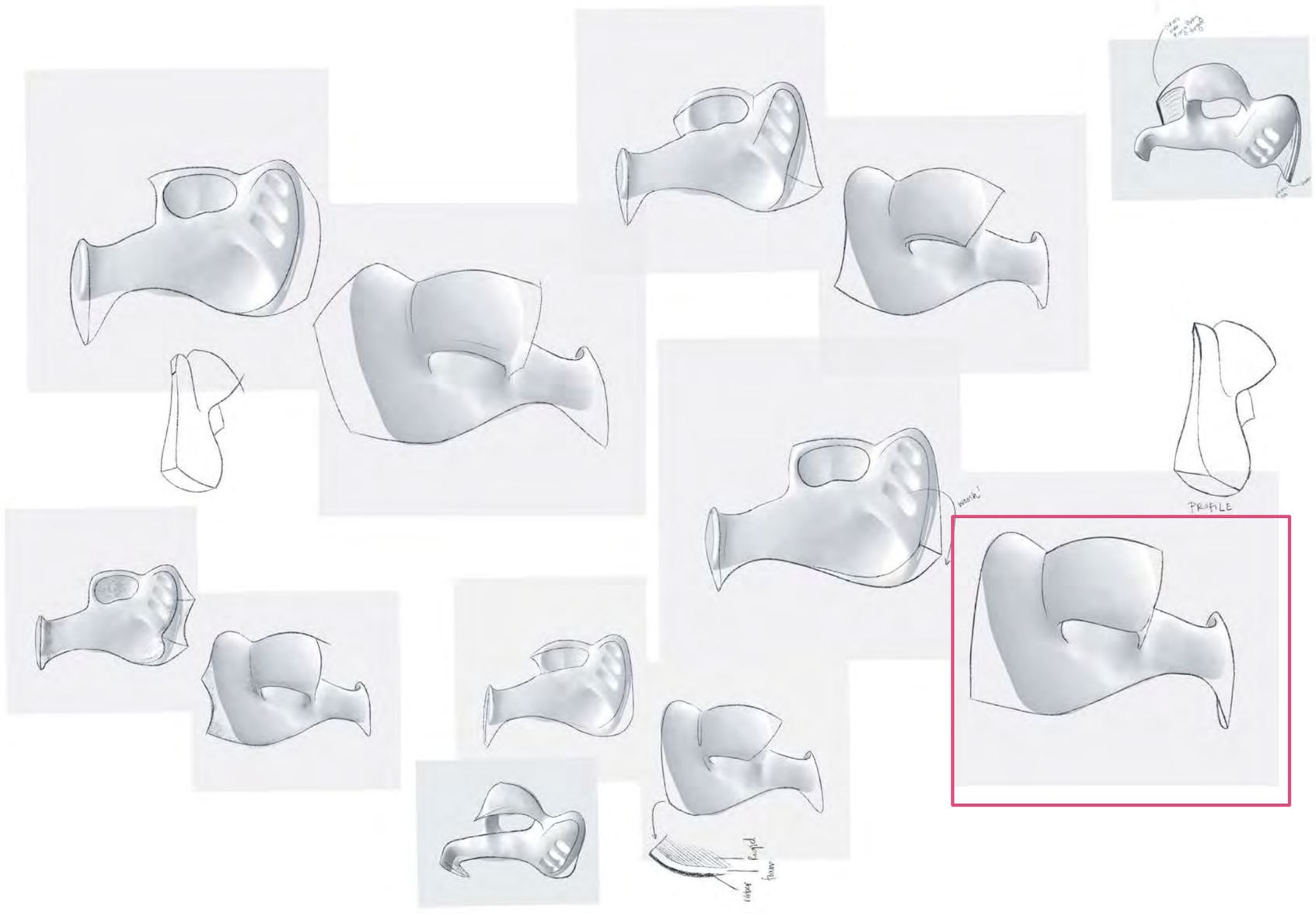
FORM / PERFORMANCE AESTHETIC

VELOX *PUSH GLOVE SKETCHES*



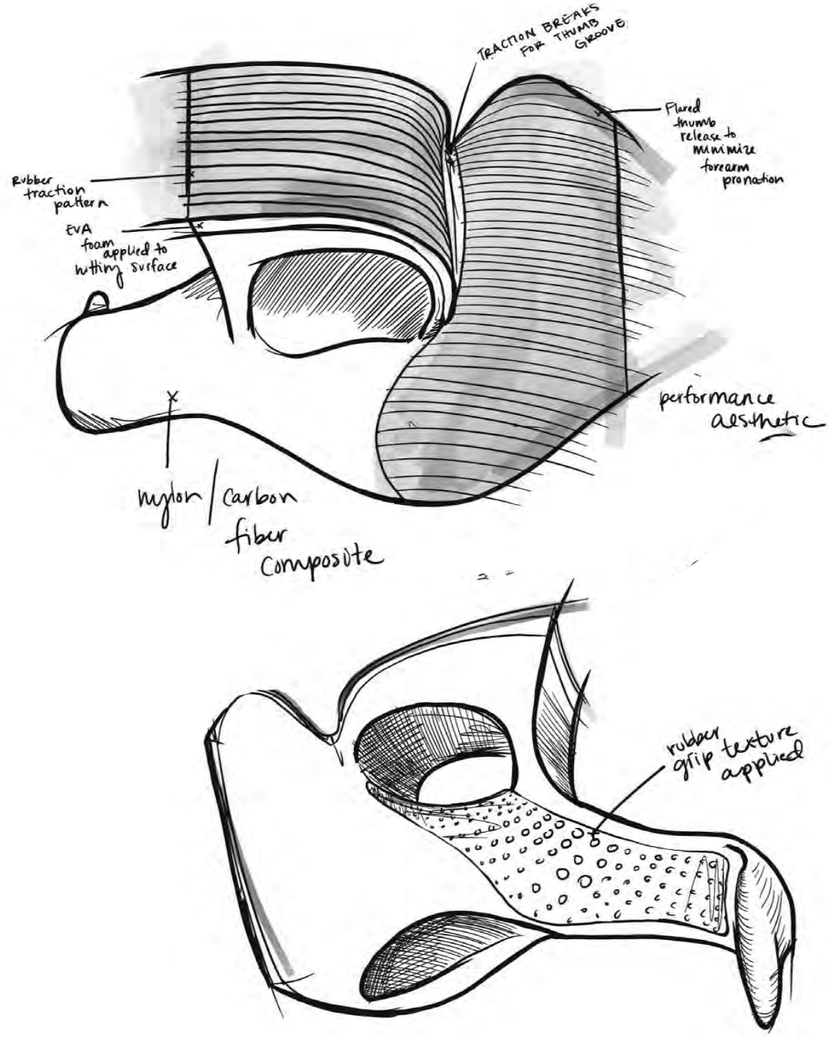
FORM / PERFORMANCE AESTHETIC

VELOX *PUSH GLOVE SKETCHES*



FORM / PERFORMANCE AESTHETIC

VELOX *PUSH GLOVE PROTOTYPING*



FORM / FIT / ERGONOMICS / WEAR TEST

VELOX *PUSH GLOVE VALIDATION*

FIT PERCEPTION & TEST FEEDBACK

Susannah Scaroni & Arielle Rausin, US Wheelchair Racing Paralympic Athletes

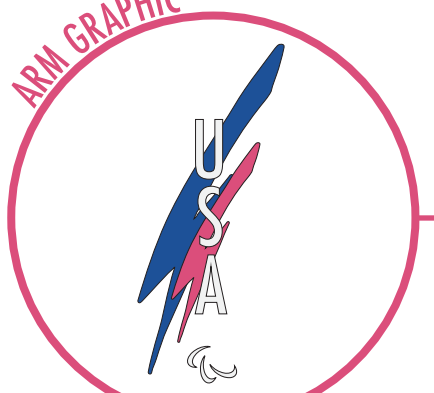
"IN INITIAL TESTS JUST PUSHING DOWN MY STREET, I COULD TELL IT WAS DOING WHAT YOU WERE TRYING TO ACCOMPLISH WITH MINIMIZING PRONATION WITH MY WRIST"

"I THINK IT MIGHT ASO BE BENEFICIAL FOR CLIMBING WITH THE BIGGER SURFACE"

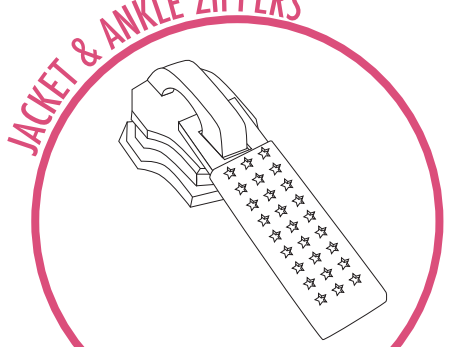
"I WAS SURPRISED, THE EDGE DIDN'T GET STUCK LIKE I THOUGHT IT WOULD. I HAD A SMOOTH FLICK AT 6:00 ON THE RING."

VELOX *WEATHERPROOF TRAINING APPAREL*

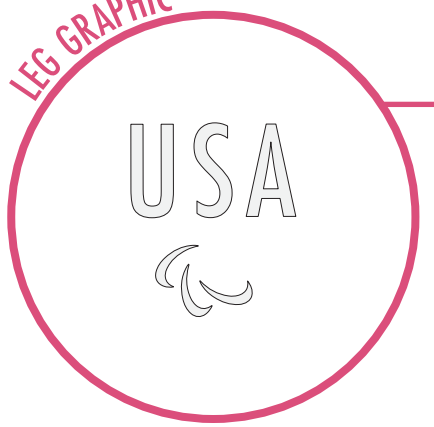
ARM GRAPHIC

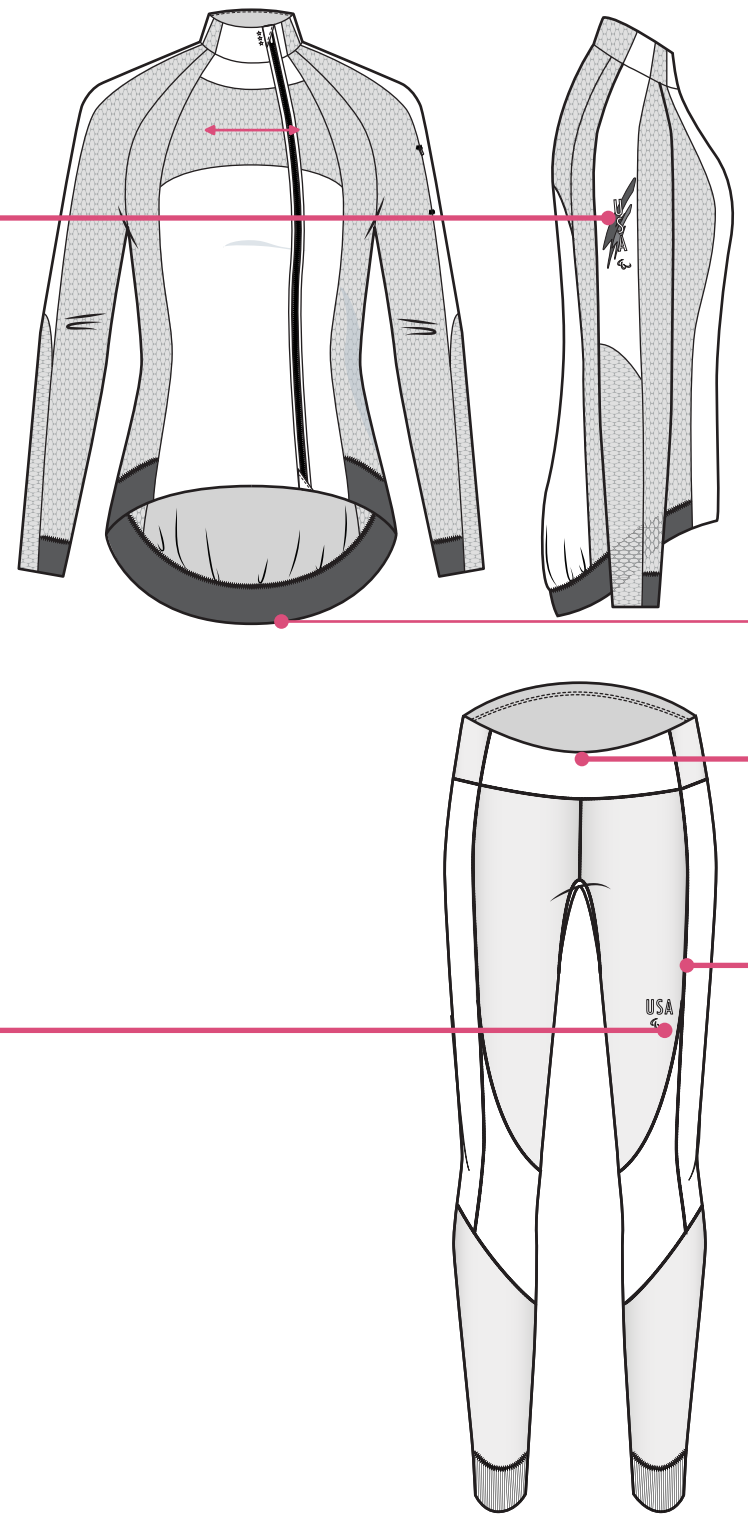


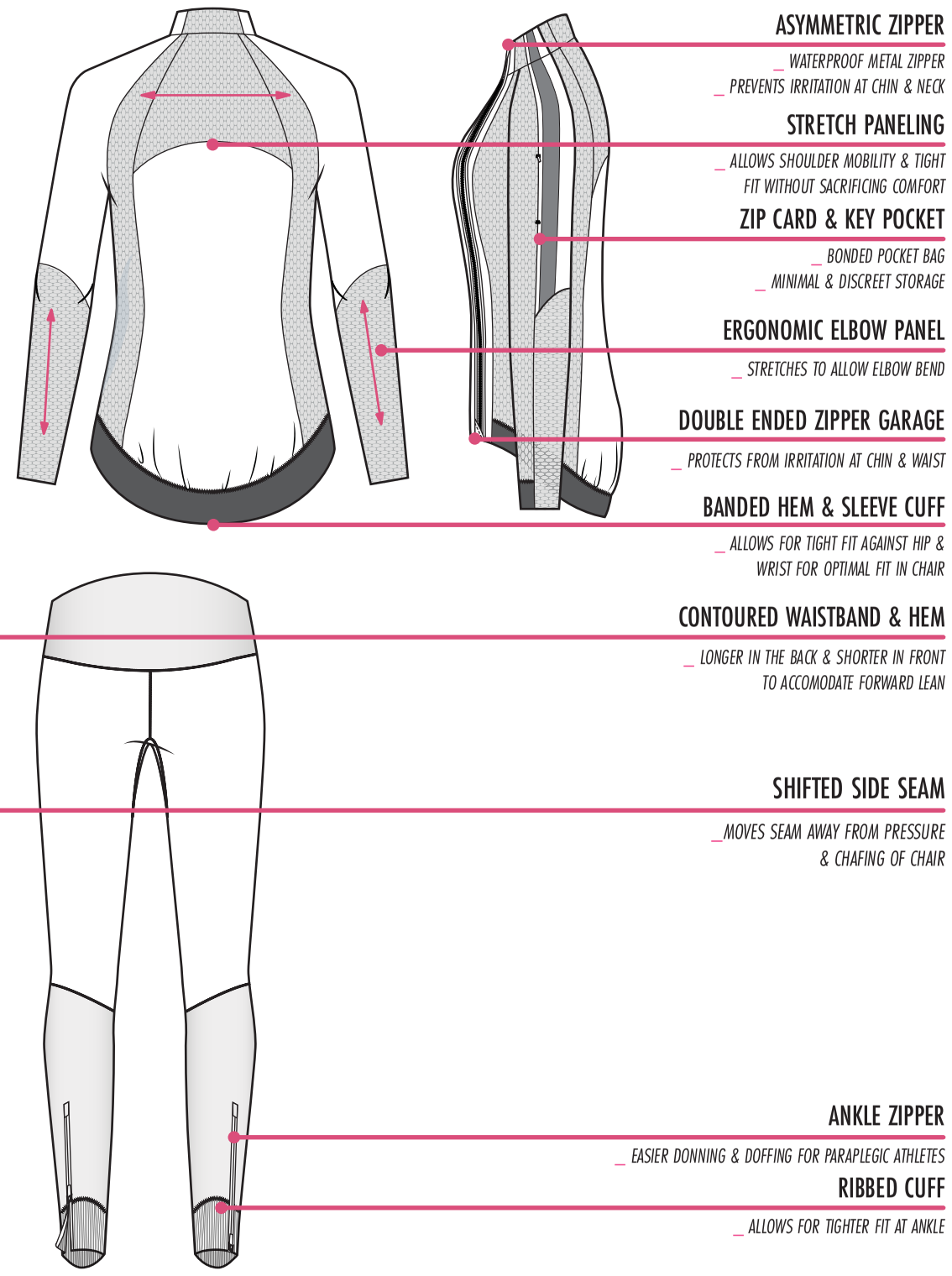
JACKET & ANKLE ZIPPERS



LEG GRAPHIC







ASYMMETRIC ZIPPER
_ *WATERPROOF METAL ZIPPER*
_ *PREVENTS IRRITATION AT CHIN & NECK*

STRETCH PANELING
_ *ALLOWS SHOULDER MOBILITY & TIGHT FIT WITHOUT SACRIFICING COMFORT*

ZIP CARD & KEY POCKET
_ *BONDED POCKET BAG*
_ *MINIMAL & DISCREET STORAGE*

ERGONOMIC ELBOW PANEL
_ *STRETCHES TO ALLOW ELBOW BEND*

DOUBLE ENDED ZIPPER GARAGE
_ *PROTECTS FROM IRRITATION AT CHIN & WAIST*

BANDED HEM & SLEEVE CUFF
_ *ALLOWS FOR TIGHT FIT AGAINST HIP & WRIST FOR OPTIMAL FIT IN CHAIR*

CONTOURED WAISTBAND & HEM
_ *LONGER IN THE BACK & SHORTER IN FRONT TO ACCOMODATE FORWARD LEAN*

SHIFTED SIDE SEAM
_ *MOVES SEAM AWAY FROM PRESSURE & CHAFING OF CHAIR*

ANKLE ZIPPER
_ *EASIER DONNING & DOFFING FOR PARAPLEGIC ATHLETES*

RIBBED CUFF
_ *ALLOWS FOR TIGHTER FIT AT ANKLE*

JACKET

MATERIALS:

GORE TEX™ 1-WAY STRETCH
_ *BREATHABLE WEATHER PROTECTION*
_ *ALLOWS FOR TIGHTER FIT & IMPROVED MOBILITY*

NEOPRENE STRETCH
_ *LASER CUT EDGES*
_ *TIGHT FIT AGAINST BODY*

GORE TEX™ WOVEN
_ *BREATHABLE WEATHER PROTECTION*

CONSTRUCTION:
_ *CUT & SEWN WITH SERGED OVERLOCK STITCHING*
_ *SEAM SEALED FINISH*
_ *HEAT PRESS GRAPHICS*
_ *BONDED HEM SLEEVE FINISH*

LEGGINGS

MATERIALS:

STRETCH WOVEN POLYESTER
_ *WATER REPELLANT & WINDPROOF*
_ *STRETCHABLE & TIGHT FITTING*

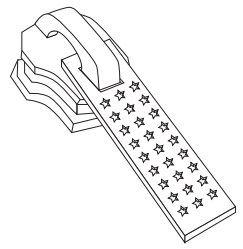
SPANDEX/POLYESTER KNIT
_ *4-WAY STRETCH*
_ *SLICK FINISH ALLOWS ATHLETES TO SLIP INTO CHAIRS EASILY*

RIB KNIT
_ *4-WAY STRETCH SPANDEX/POLYESTER*
_ *SLICK FINISH ALLOWS ATHLETES TO SLIP INTO CHAIRS EASILY*

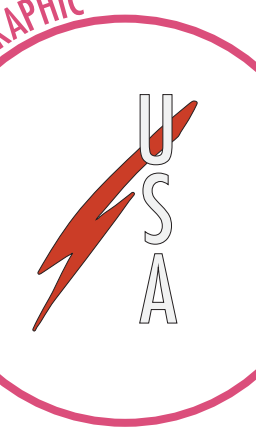
CONSTRUCTION:
_ *CUT & SEWN WITH FLATLOCK STITCHING*
_ *HEAT PRESS GRAPHICS*

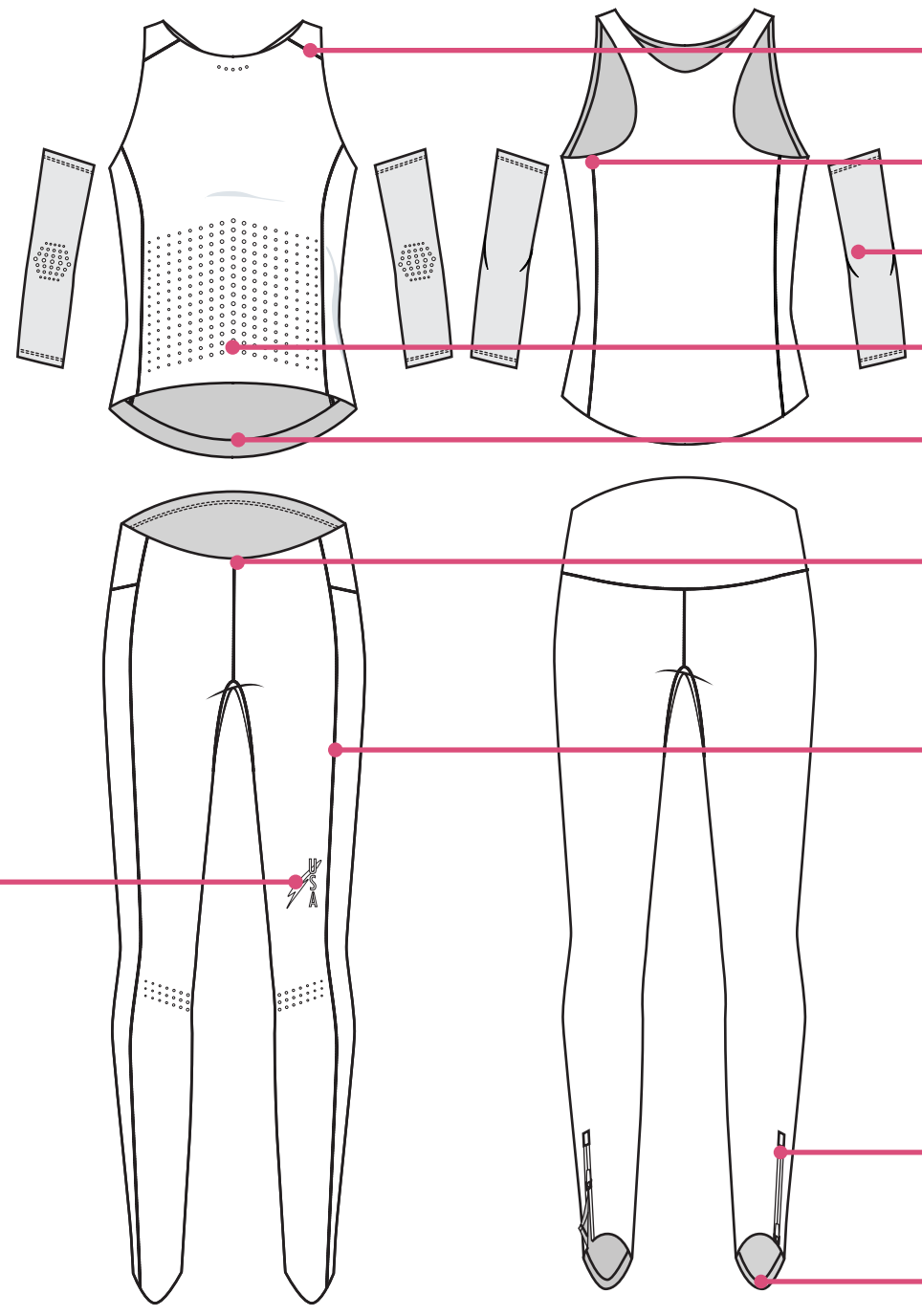
VELOX *RACING KIT*

ANKLE ZIPPERS



LEG GRAPHIC





REINFORCED SHOULDER SEAM
_ PREVENTS TEARS AT SHOULDER STRESS POINT

PANELED DESIGN
_ LESSENS LIKLIHOOD OF UNDERARM CHAFING

3/4 ARM SLEEVE
_ PROTECTS RACER'S ARMS FROM ABRASION

BODY MAPPED VENTILATION
_ SEAMLESS SWEAT MANAGEMENT CONCENTRATED IN SWEAT ZONES

CONTOURED HEM
_ ACCOMODATES FORWARD LEAN & PREVENTS FABRIC FROM BUNCHING UP IN FRONT

FOLDOVER CONTOURED WAISTBAND
_ FOLDED & BONDED CONSTRUCTION
_ MINIMIZES BULK, PREVENTS CHAFING & IRRITATION

SHIFTED SIDE SEAM
_ MOVES SEAM AWAY FROM PRESSURE & CHAFING OF CHAIR

ANKLE ZIPPER
_ EASIER DONNING & DOFFING FOR PARAPLEGIC ATHLETES

CONTOURED ANKLE
_ BETTER ACCOMOCATE FLEXED POSITION OF FOOT

SINGLET

MATERIALS:

POLYESTER/SPANDEX KNIT
_ 4 WAY STRETCH
_ ALLOWS FOR OPTIMAL MOBILITY

CONSTRUCTION:
_ CUT & SEWN WITH FLATLOCK STITCHING
_ LASER CUT & BONDED EDGES
_ SUBLIMATED GRAPHICS

LEGGINGS

MATERIALS:

SLICK POLYESTER/SPANDEX KNIT
_ 4-WAY STRETCH
_ STRETCHY & TIGHT FITTING

CONSTRUCTION:
_ CUT & SEWN WITH FLATLOCK STITCHING
_ LASER CUT & BONDED EDGES
_ HEAT PRESS GRAPHICS

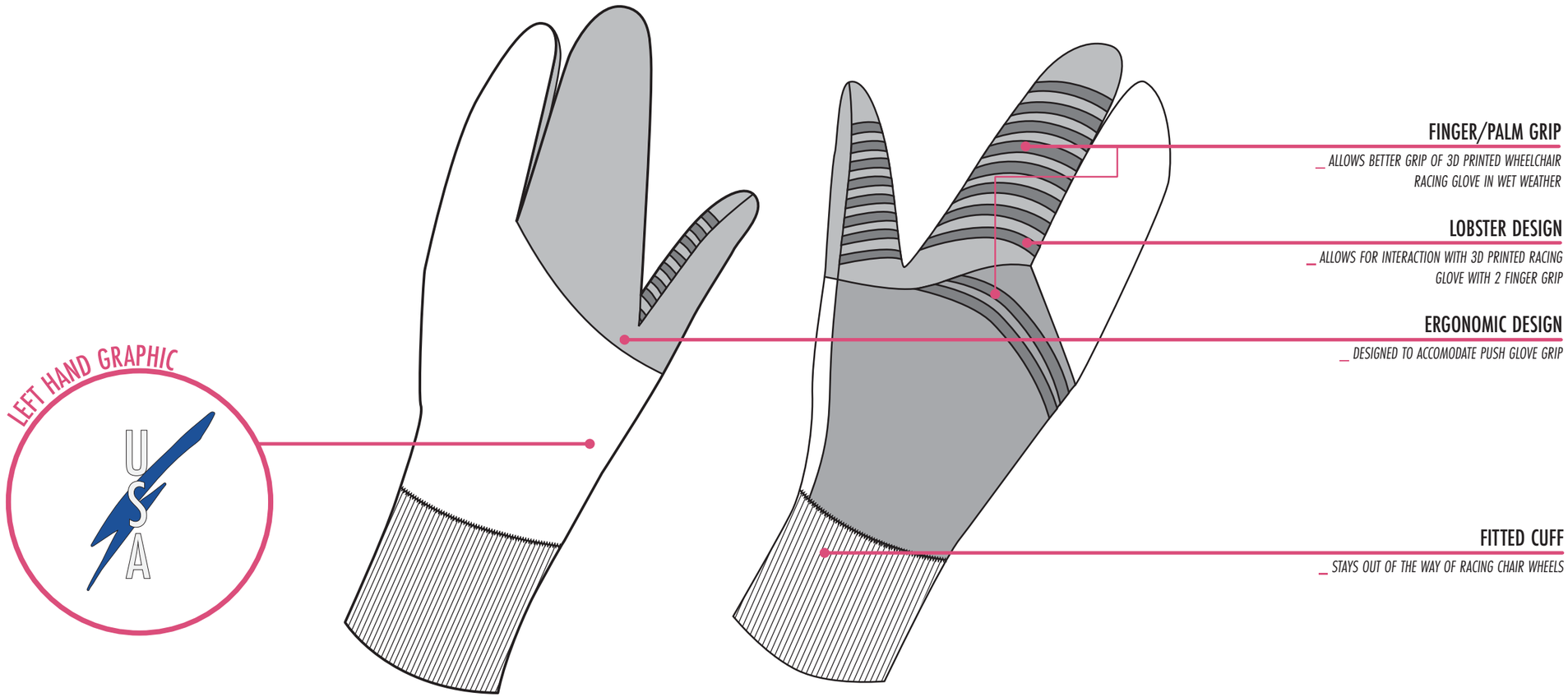
ARM SLEEVES

MATERIALS:

POLYESTER/SPANDEX/KEVLAR KNIT
_ 4-WAY STRETCH
_ PREVENTS INNER ARM ABRASION FROM CHAIR

CONSTRUCTION:
_ CUT & SEWN WITH FLATLOCK STITCHING
_ TURNED & COVERSTITCHED EDGES
_ SUBLIMATED GRAPHICS

VELOX *WEATHER MIT*



FINGER/PALM GRIP
_ ALLOWS BETTER GRIP OF 3D PRINTED WHEELCHAIR RACING GLOVE IN WET WEATHER

LOBSTER DESIGN
_ ALLOWS FOR INTERACTION WITH 3D PRINTED RACING GLOVE WITH 2 FINGER GRIP

ERGONOMIC DESIGN
_ DESIGNED TO ACCOMODATE PUSH GLOVE GRIP

FITTED CUFF
_ STAYS OUT OF THE WAY OF RACING CHAIR WHEELS

MIT

MATERIALS:

GORE TEX™ WOVEN & WICKING FLEECE
_ BREATHABLE WEATHER PROTECTION
_ WARMTH ON EXPOSED FINGERS

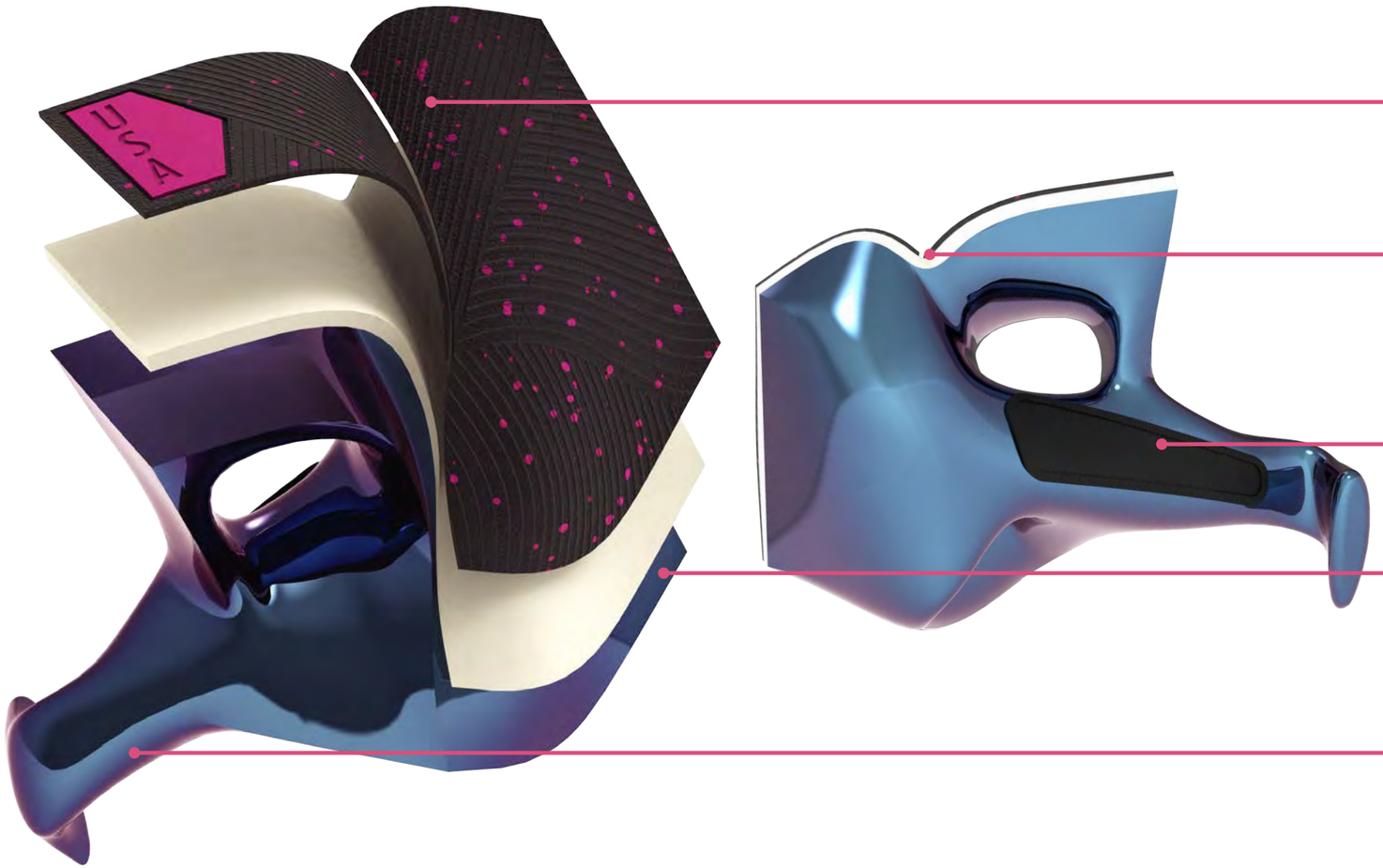
BRUSHED BACK POLYESTER/SPANDEX
_ TIGHT FITTING THERMAL PROTECTION
_ MOISTURE WICKING FOR ATHLETE COMFORT

RIB KNIT
_ POLYESTER/SPANDEX KNIT
_ ALLOWS TIGHT FIT AROUND WRIST

CONSTRUCTION:

_ CUT & SEWN WITH LOCKSTICH & OVERLOCK STITCHING
_ HEAT PRESS GRAPHICS
_ SILICON GRIP LINES

VELOX *PUSH GLOVE*



TREAD PATTERN
_ LENDS PERFORMANCE AESTHETIC
_ ENHANCES TRACTION ON PUSH RIM

GROOVED SHAPE
_ EFFICIENT FORCE TRANSFER FROM ATHLETE TO PUSH RIM

GRIP
_IMPROVED GRIP IN HUMID CONDITIONS

FLARED THUMB RELEASE
_REDUCES FOREARM PRONATION TO MINIMIZE WRIST OVERUSE INJURY
_INCREASED SURFACE AREA IS BENEFICIAL FOR HILL CLIMBING DUE TO LONGER CONTACT TIME

ERGONOMIC HANDLE
_ERGONOMIC FIT, EXCELLENT FORCE TRANSFER

PUSH GLOVE

MATERIALS:

CARBON FIBER/NYLON COMPOSITE
_ REPONSIVE FORCE TRANSFER FROM ATHLETE TO PUSH RIM

CONSTRUCTION:
_ 3D SCAN MOLDED GLOVES OF ATHLETE
_ COMBINE WITH BODY OF VELOX GLOVE
_ 3D PRINTED

EVA FOAM
_ PROVIDES RESPONSIVE CUSIONING TO WRIST JOINTS
_ ALLOWS FOR BETTER TRACTION WITH FOAM DEFORMATION

CONSTRUCTION:
_ INJECTION MOLDED

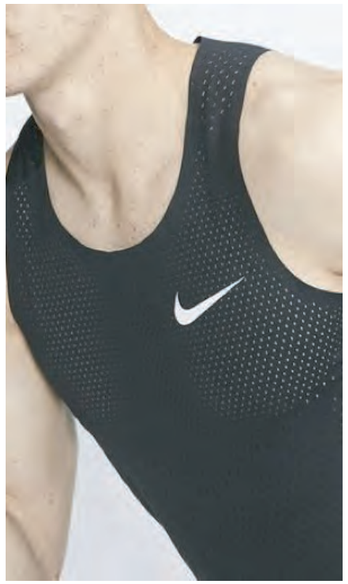
VIBRAM® MEGAGRIP RUBBER
_ UNPARALLELED TRACTION IN WET & DRY CONDITIONS
_ ENHAANCES DURABILITY OF GLOVE

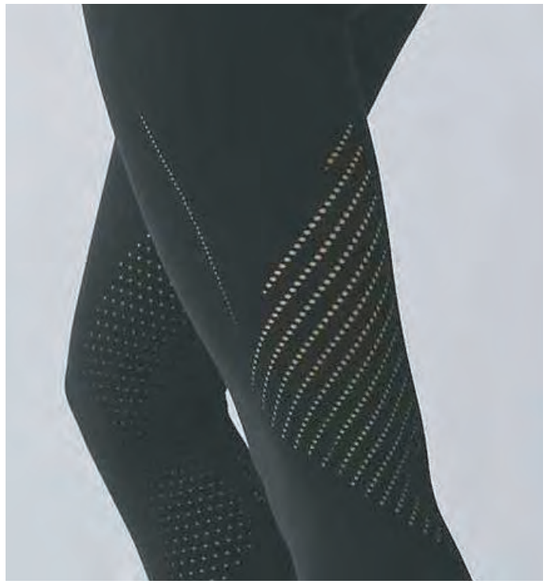
CONSTRUCTION:
_ MOLDED RUBBER

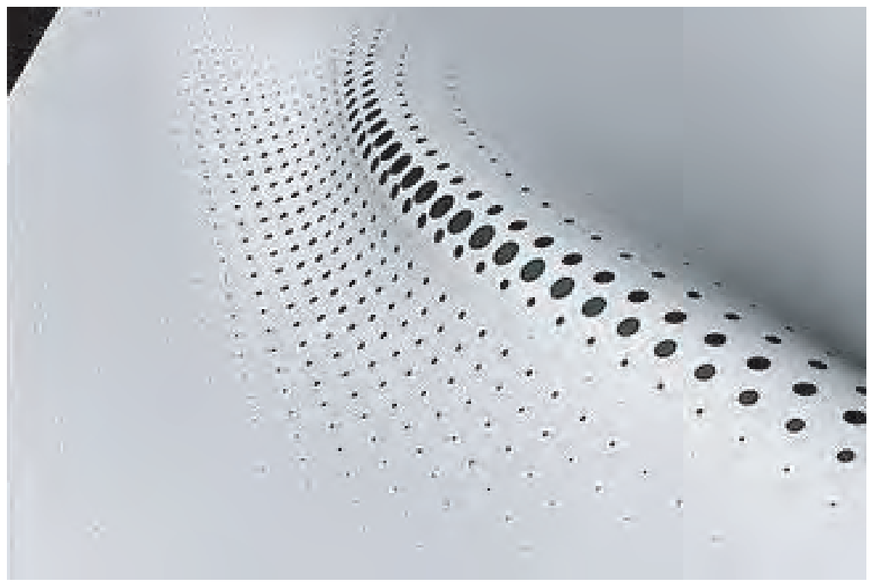
SOFT SHEET RUBBER
_ PREVENTS DROPPED GLOVES

CONSTRUCTION:
_ STAMPED SHEET RUBBER

VELOX *APPAREL SILHOUETTE*

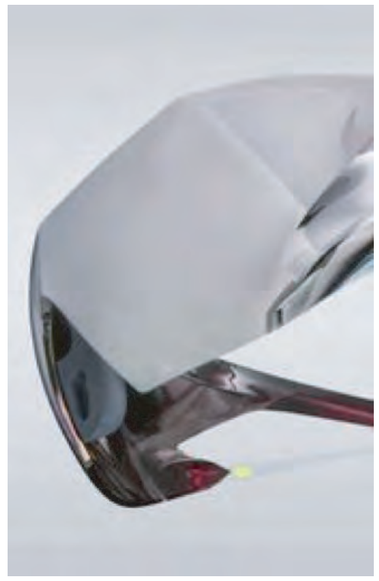


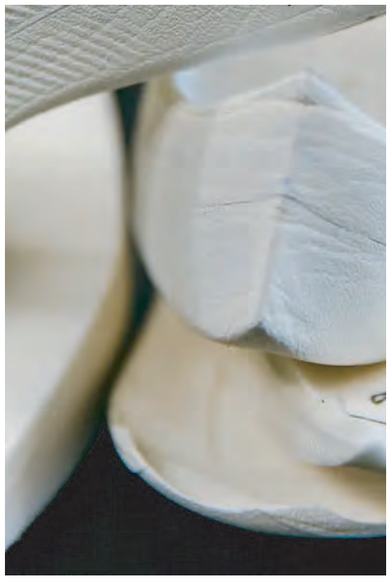




SLEEK / ERGONOMIC / MINIMAL / PERFORMANCE DRIVEN

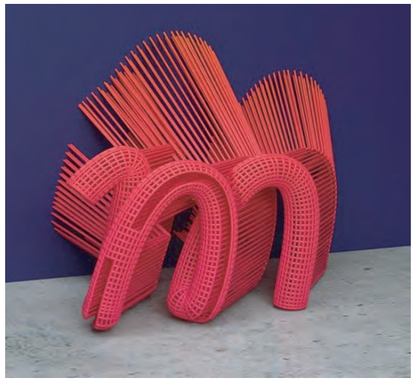
VELOX *GLOVE SILHOUETTE INSPIRATION*

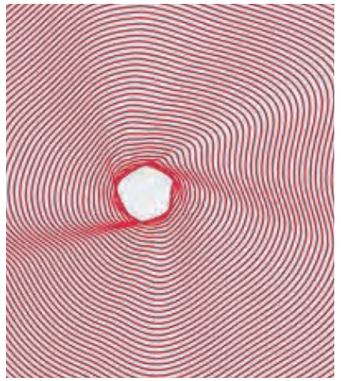


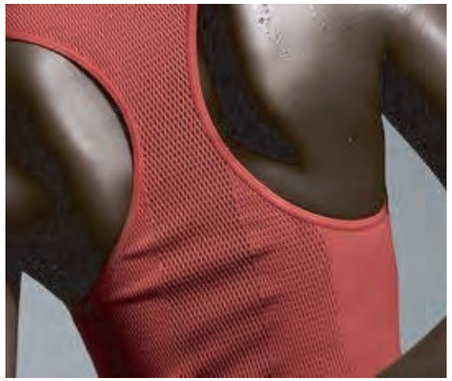


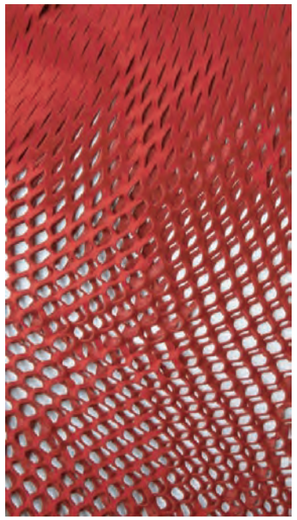
SLEEK / FAST / PERFORMANCE

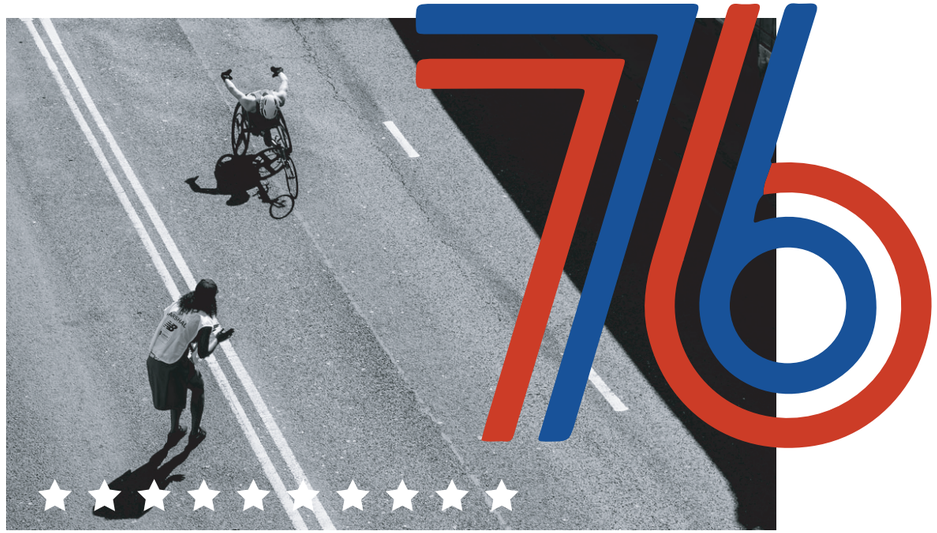
VELOX *UNIFORM MOOD & COLOR*







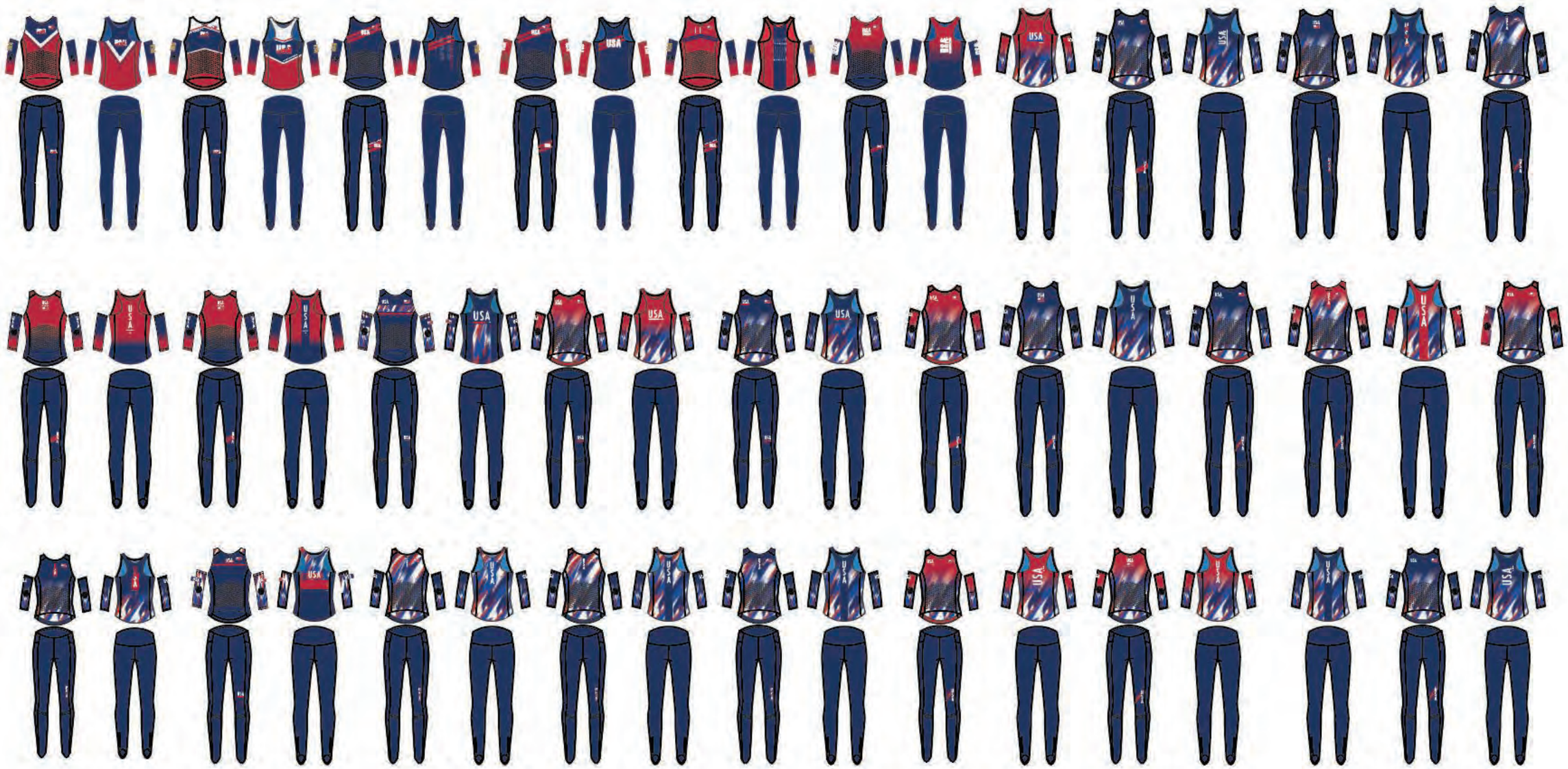




NEW NOSTALGIA

Emerging from global pandemic, we are reminded of the true beauty of the Olympic & Paralympic games. Without competitive sport, we've looked to games past with nostalgia—not for aggression or competition, but for the togetherness that our teams bring. We've also craved new technological advancements, both for health & safety, and as a sign that society continues forging ahead. "Ad astra per aspera", to the stars through difficulty, is the phrase of the day, with the stars of the USA symbolizing resilience—our ability to rise above and come together. A juxtaposition of retro and new, young and old, coming together and rising above. Showcasing the true beauty of The Games, we celebrate the old and welcome in a brighter and more inclusive future.

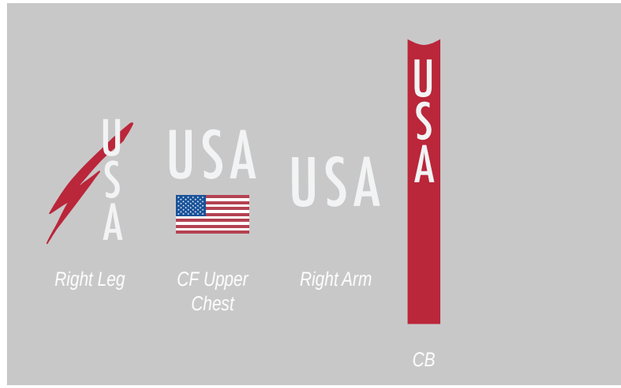
VELOX *UNIFORM GRAPHIC IDEATION*



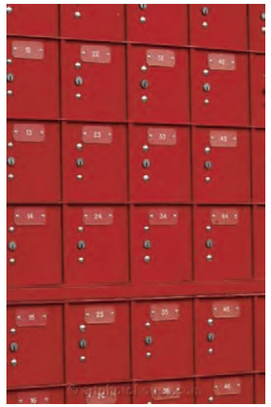
VELOX *UNIFORM GRAPHIC APPLICATION*

PRINT

GRAPHICS



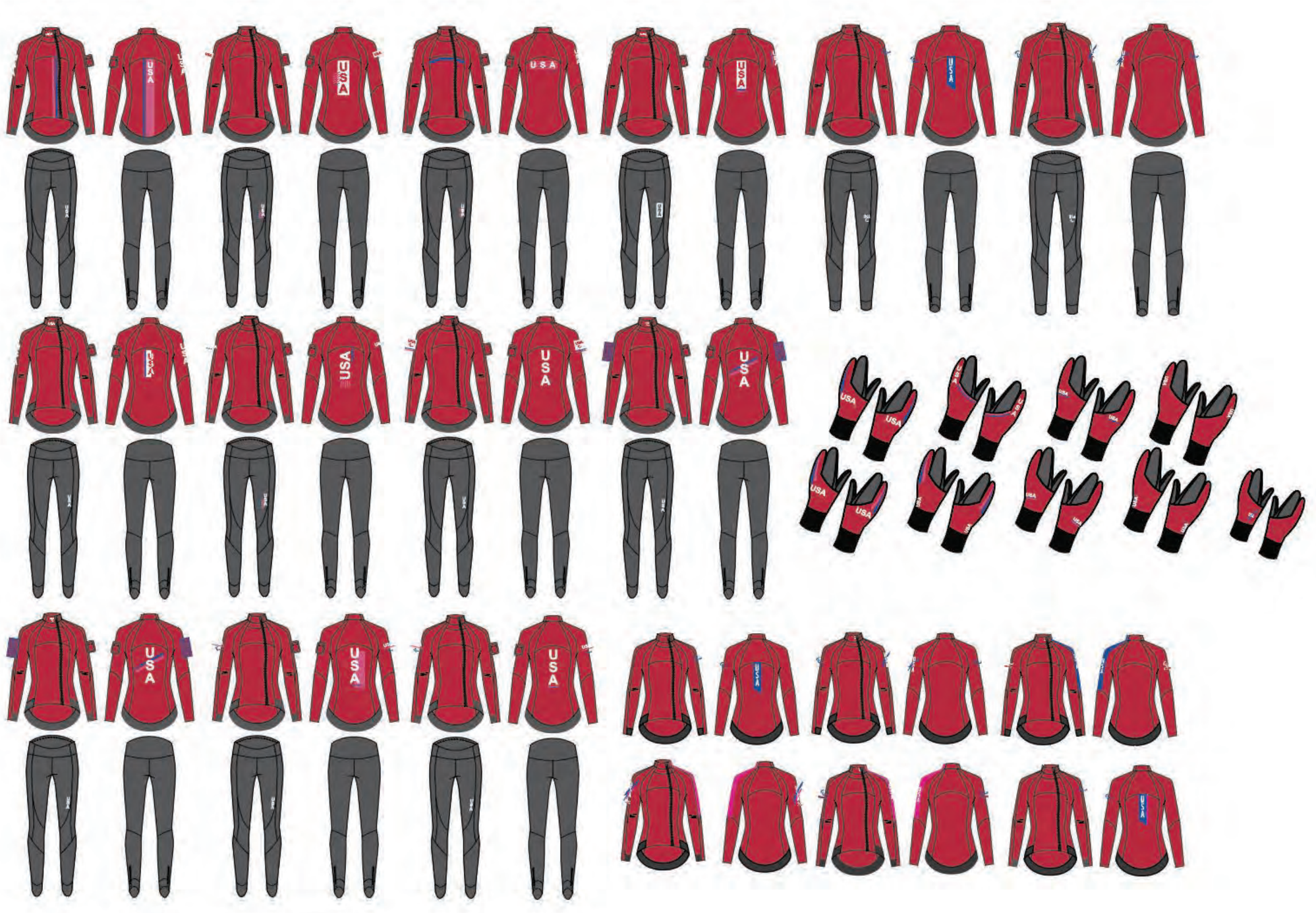
VELOX *TRAINING MOOD & COLOR*



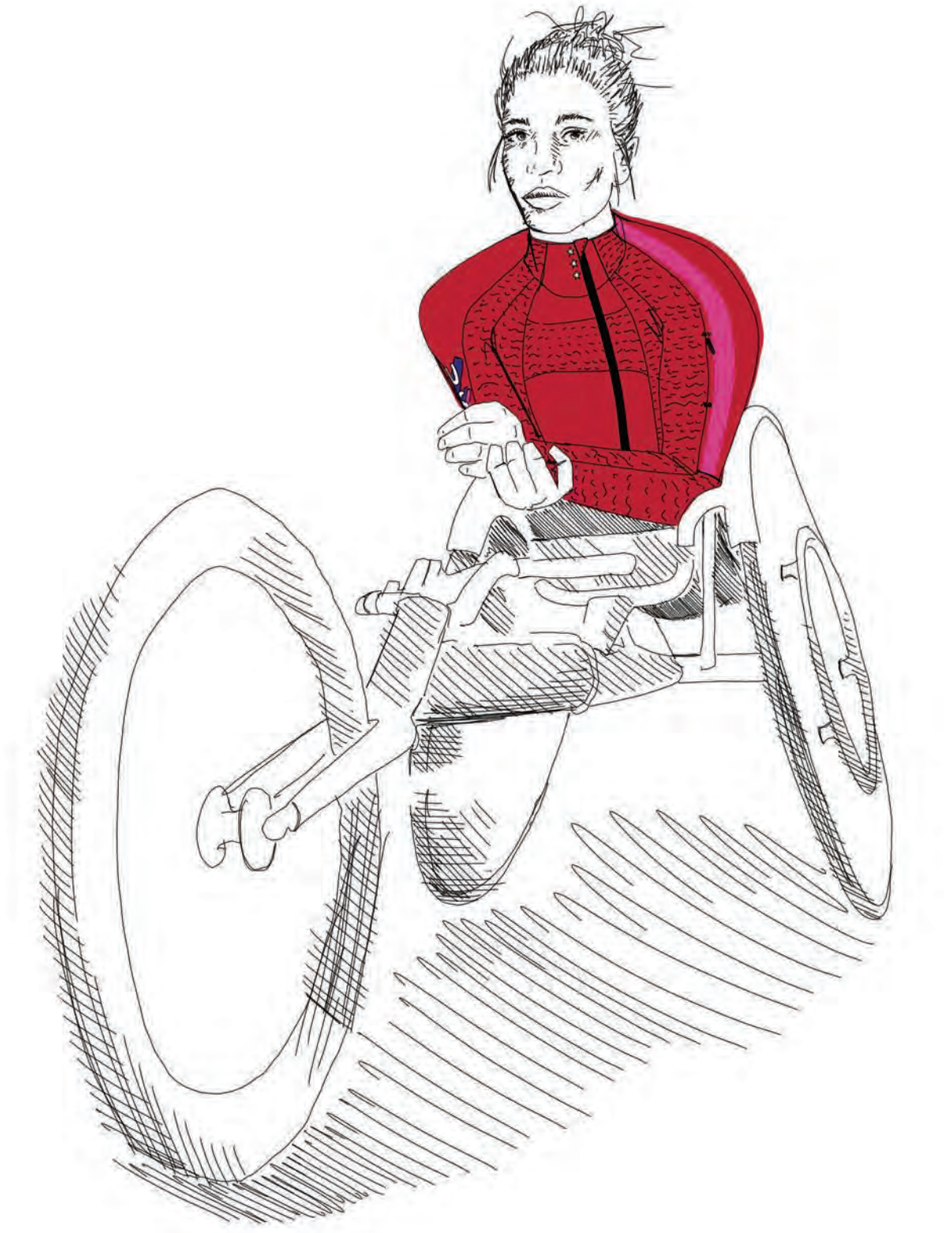
INSPIRED BY '92

A lively spirit inspires the mood & color here. Performance apparel has become so serious—as athletes strive to cut seconds from outstanding personal bests, we forget the reason we started competing in the first place. Patriotic tones of red, white, and blue are complemented by a bold and playful magenta hue, a nod to the '92 Opening Cermonies ensemble. Silhouettes remain sleek and functional as to allow athletes to compete at their best, while graphics strive to remind us of the play that originally inspired them to compete.

VELOX *TRAINING GRAPHIC IDEATION*



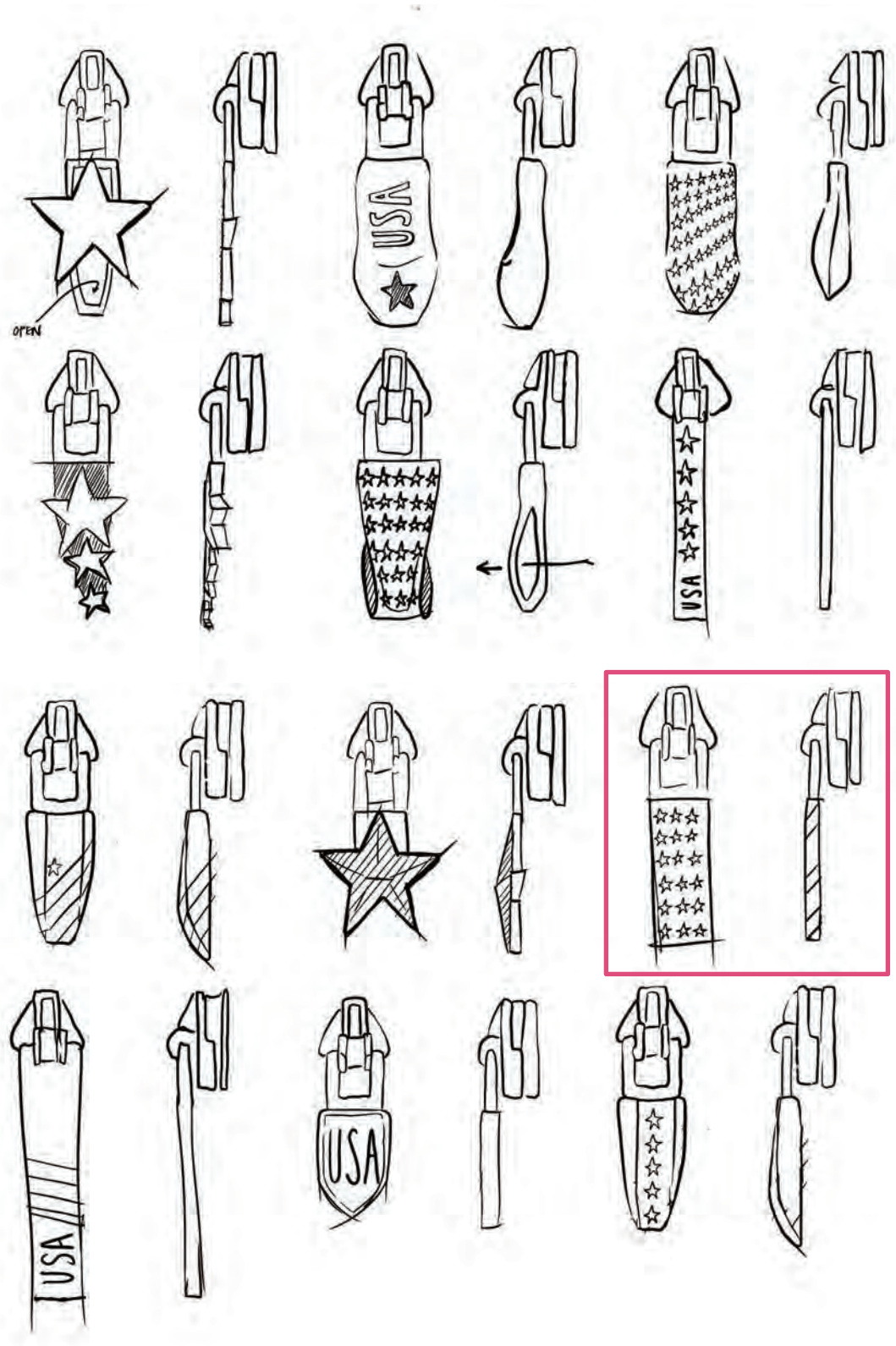
VELOX *TRAINING GRAPHIC APPLICATION*

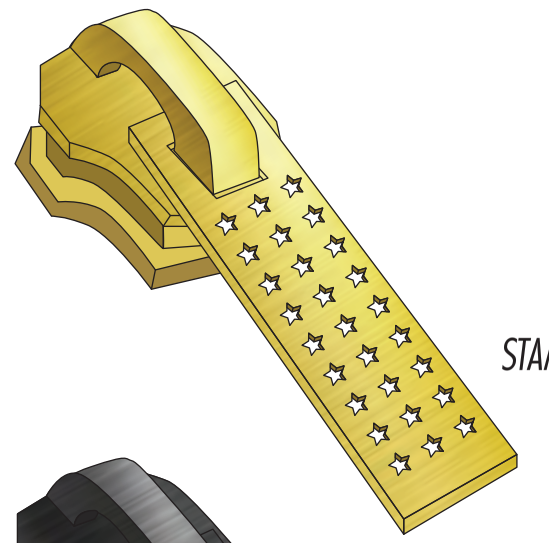


GRAPHICS

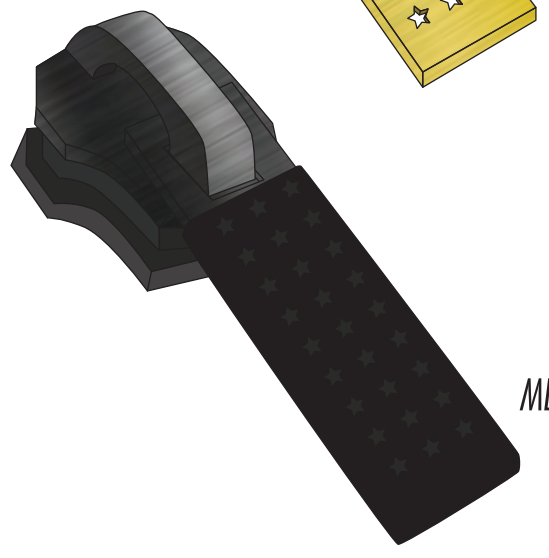
LEFT ARM *RIGHT LEG* *LEFT HAND*

VELOX *HARDWARE IDEATION*



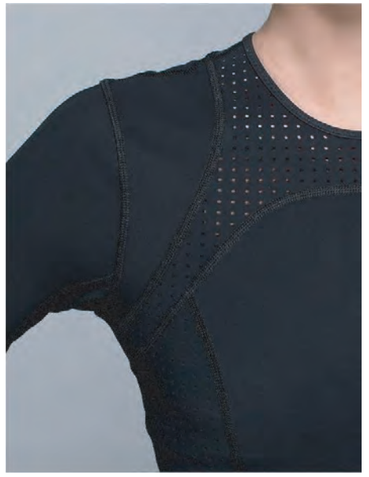


STAMPED METAL LOCKING ZIPPER

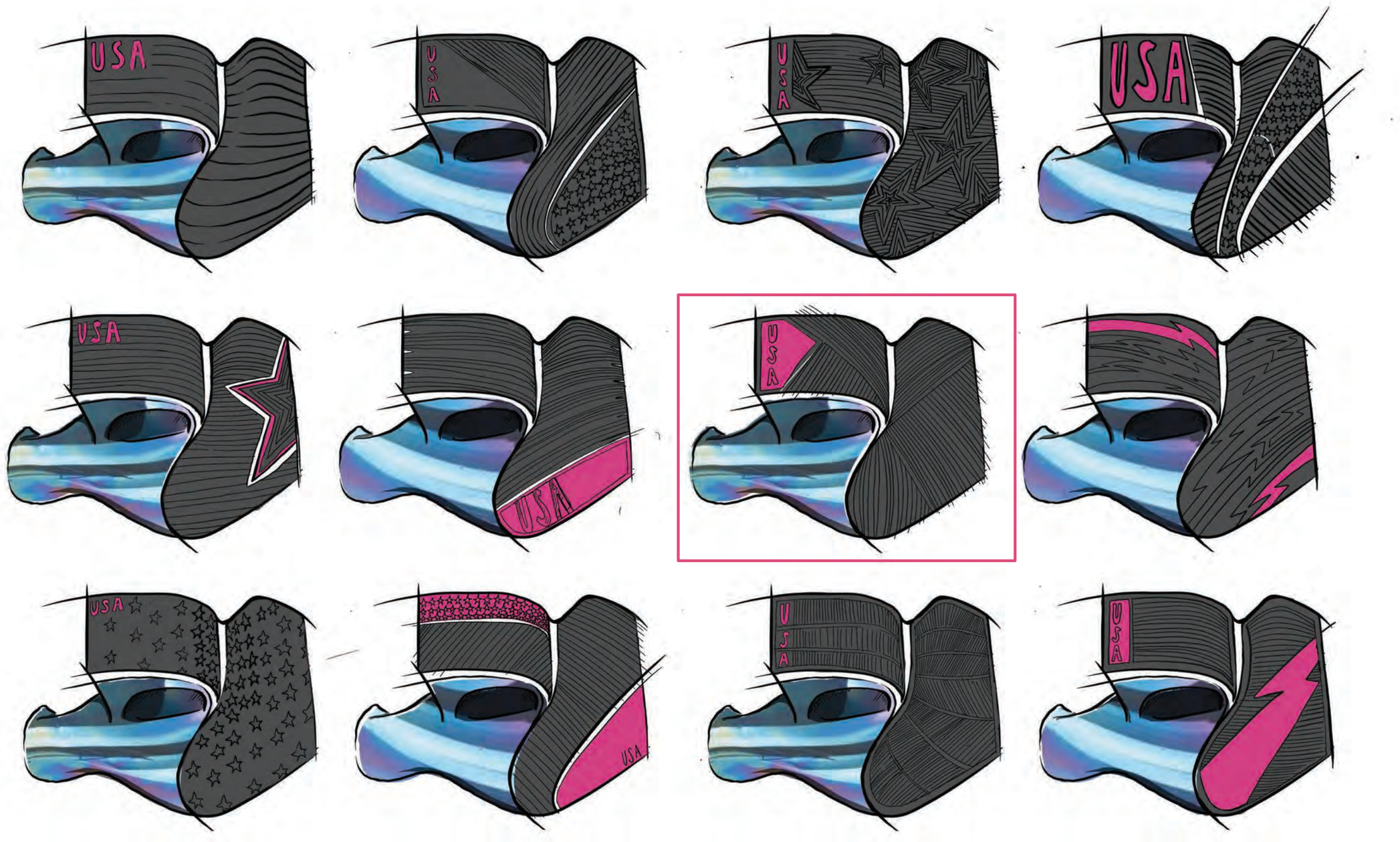


METAL ZIPPER WITH TEXTURED RUBBER PULL

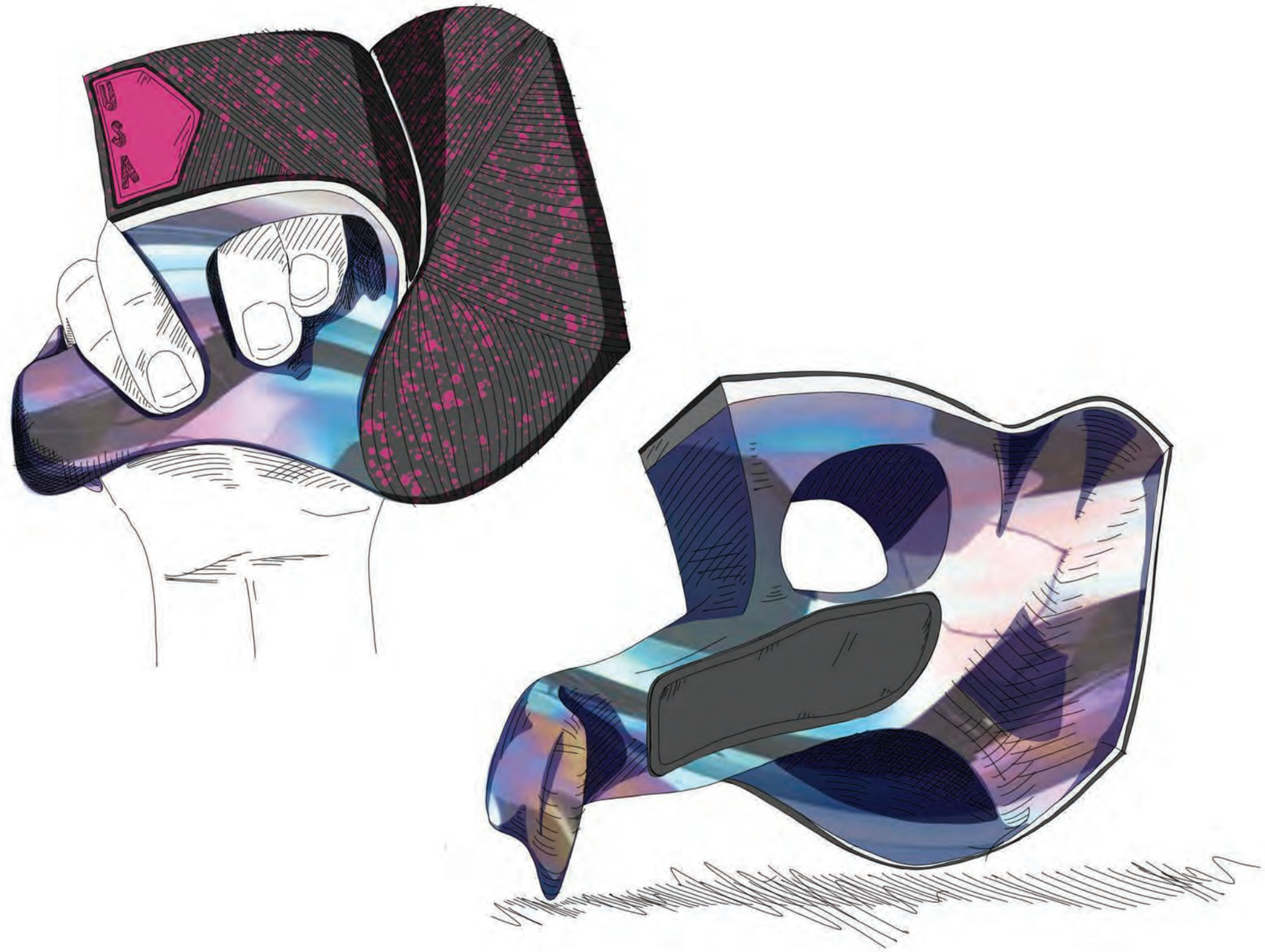
VELOX *GLOVE MOOD & COLOR*



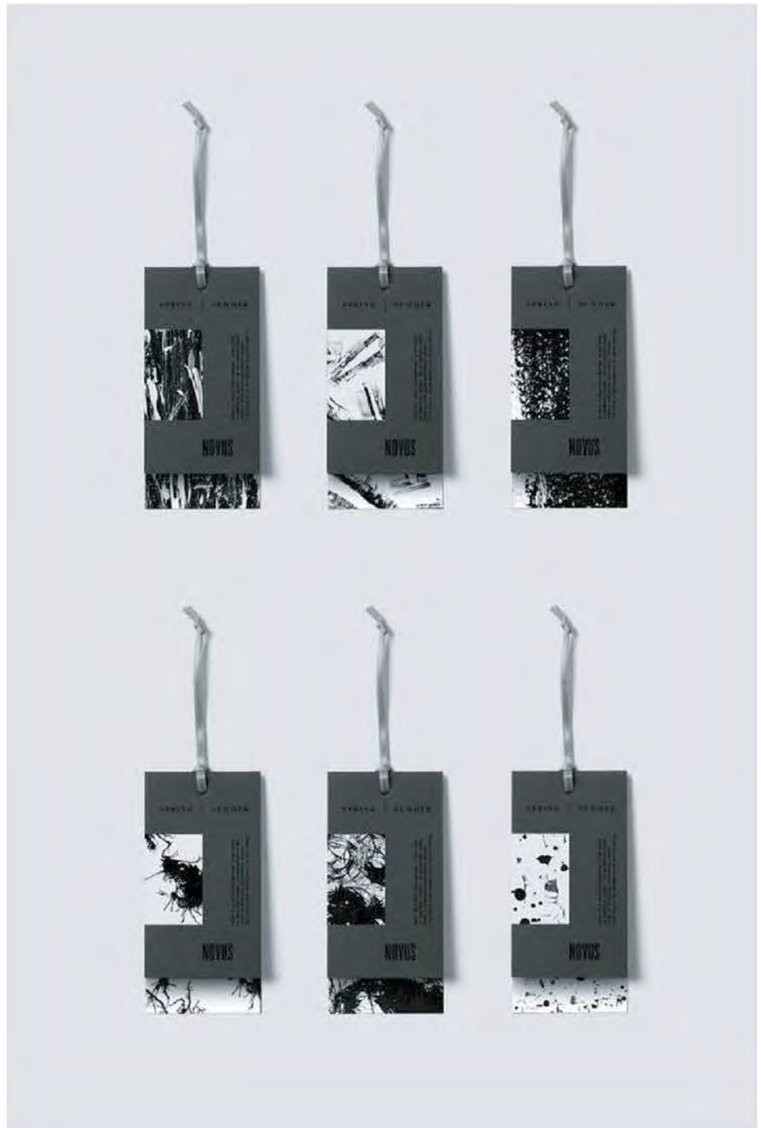
VELOX *GLOVE GRAPHIC IDEATION*



VELOX *GLOVE GRAPHIC APPLICATION*



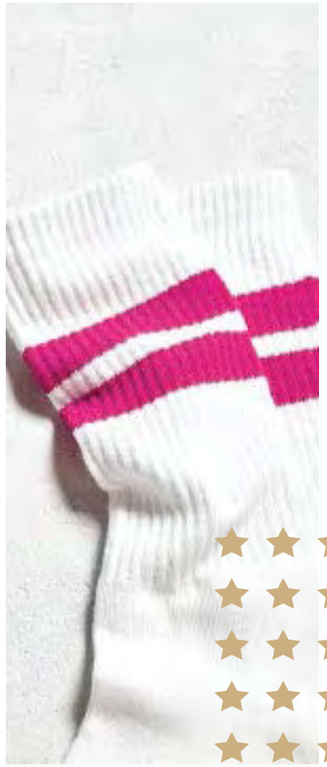
VELOX *PACKAGING PLAN*

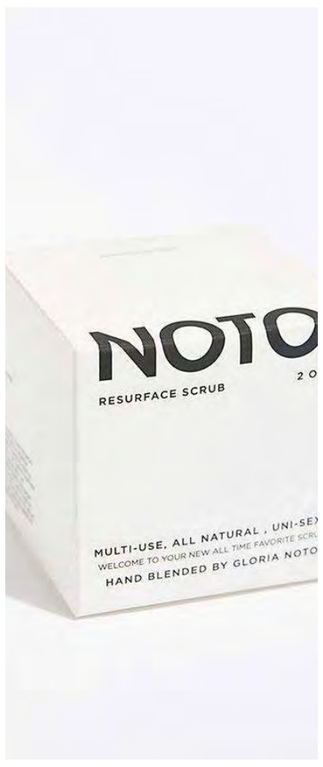


INFORMATIVE HANG TAG / HEAT PRESS LABEL / DRAWSTRING RACE BAG / STRUCTURED BOX

VELOX *BRANDING*

INSPIRATION





FONTS

A B C D E F G H I J K L M N
O P Q R S T U V W X Y Z

Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj Kk Ll Mm Nn Oo
Pp Qq Rr Ss Tt Uu Vv Ww Xx Yy Zz

Paralympics Logo

COLOR

*#CCB080 *metallic*

#F1F2F2

#DB4E7B

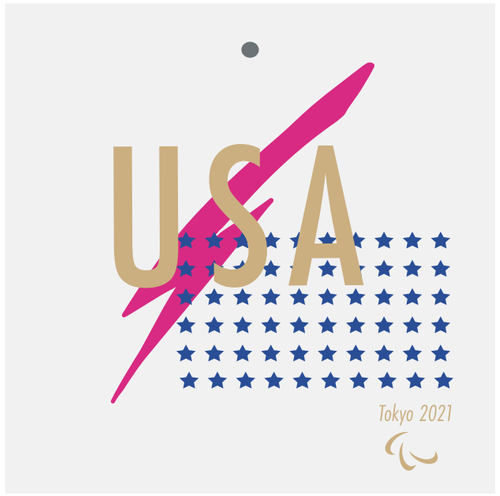
#1D5198

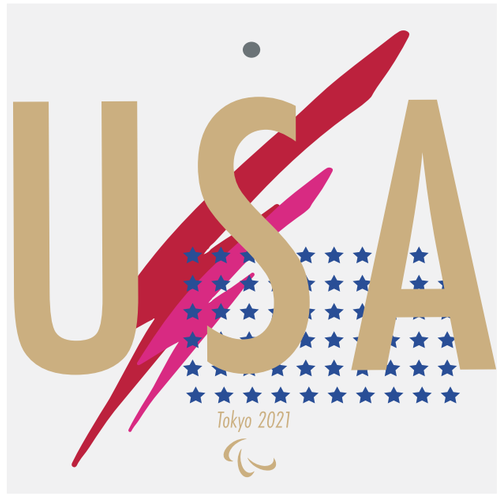
#CB3D27

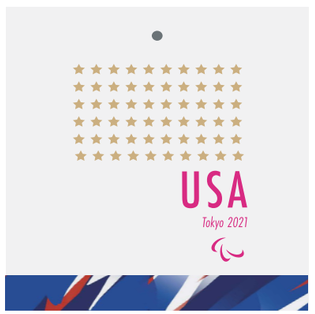
CLEAN WITH RETRO EDGE / STAR MOTIFS / GEOMETRIC

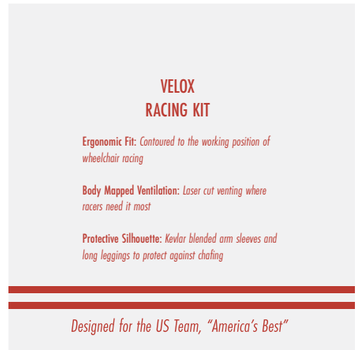
VELOX *PACKAGING IDEATION*

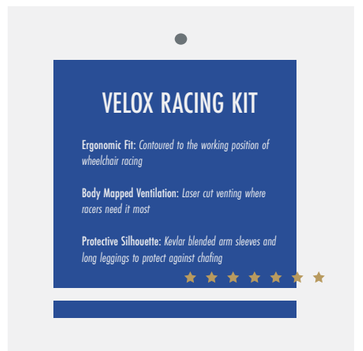
VELOX *PACKAGING IDEATION*











VELOX *PACKAGING*

HANG TAG
Informational

Designed for the US Team, "America's Best"

Front

2.5 in

2.5 in

Back

VELOX RACING KIT

Ergonomic Fit: *Contoured to the working position of wheelchair racing*

Body Mapped Ventilation: *Laser cut venting where racers need it most*

Protective Silhouette: *Kevlar blended arm sleeves and full length leggings to protect against chafing*

VELOX WEATHERPROOF TRAINING KIT

Ergonomic Fit: *Contoured to the working position of wheelchair racing*

Gore Tex™ Fabrics: *Breathable weather protection to keep athletes comfortable & dry*

Stretch Paneling: *Moves with you to allow full mobility for optimal performance*

VELOX RECOVERY CREW

Perfect for travel, cool down, and lounge, the Velox recovery crew is the type of garment that will wear in over time. A classic crisp cotton will soften more and more with every wash. This classic piece will get passed on and carry memories of the Paralympic games for years to come.

2nd Tag

2.75 in

VELOX IS A LATIN WORD MEANING "SWIFT"

The Velox collection is the first performance apparel collection designed in accordance with the unique ergonomic, physiological, and mobility needs of the elite women's wheelchair racing athlete. Extensive research & athlete insights went into creating garments designed to disappear and allow athletes to focus on performance.

Designed for the US Team, "America's Best"

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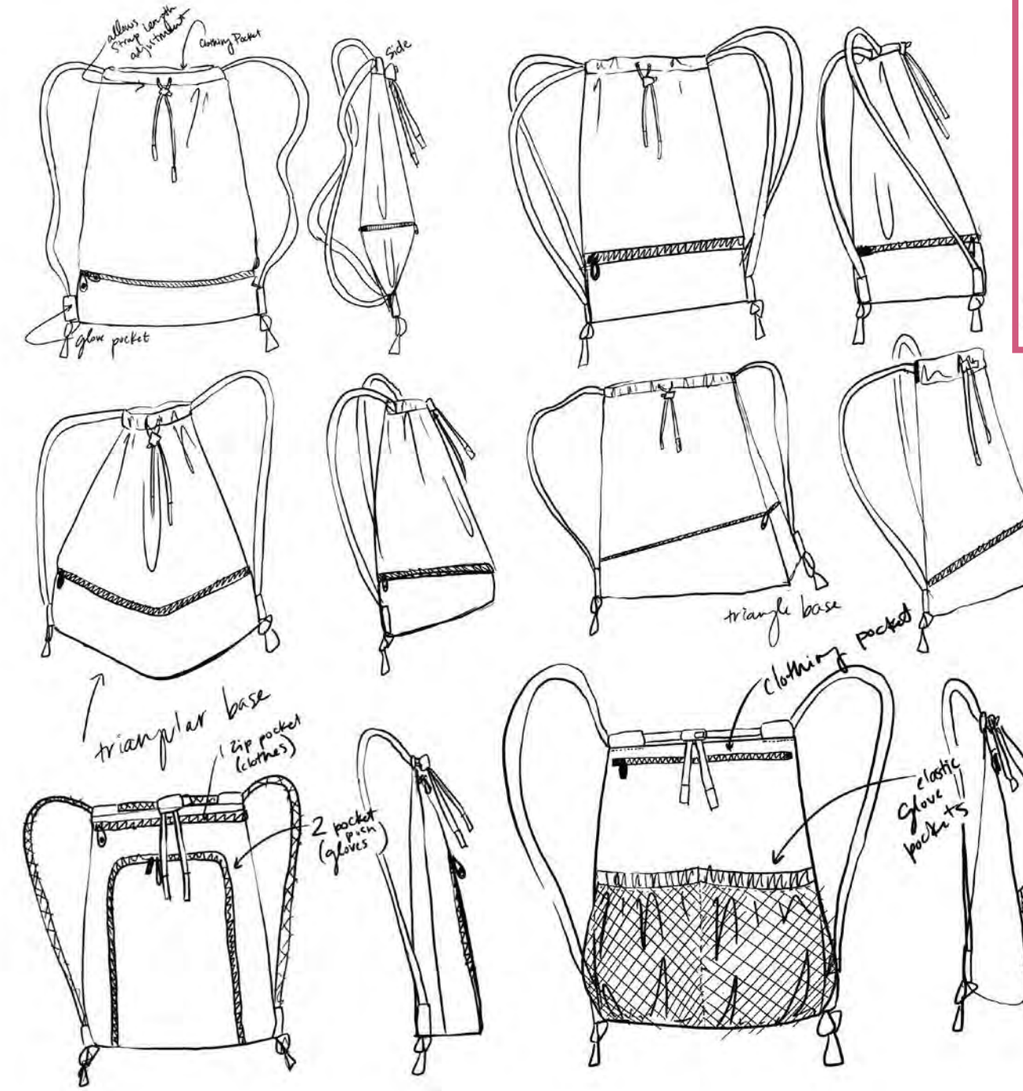
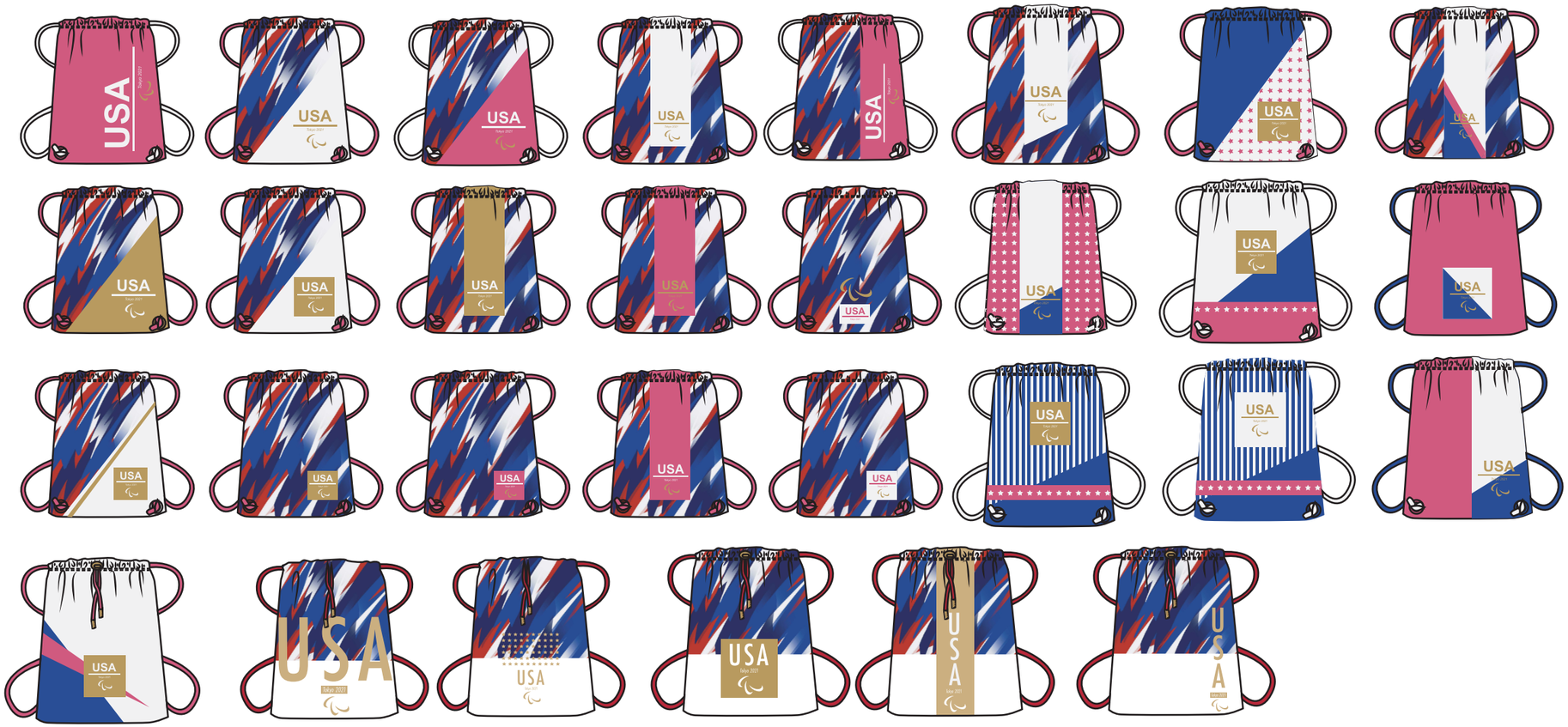
Designed for the US Team, "America's Best"

2.5 in

VELOX *PACKAGING IDEATION*

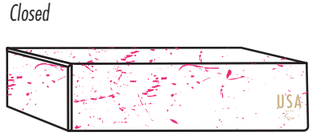


VELOX *PACKAGING IDEATION*



VELOX *PACKAGING IDEATION*

Closed



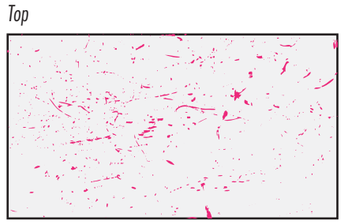
Open

Closed

Open

Open

Top



Top

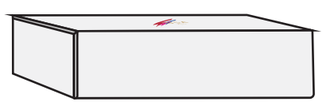
Closed

Open

Closed

Open

Closed



Open

Top

Top

Top

VELOX *PACKAGING*

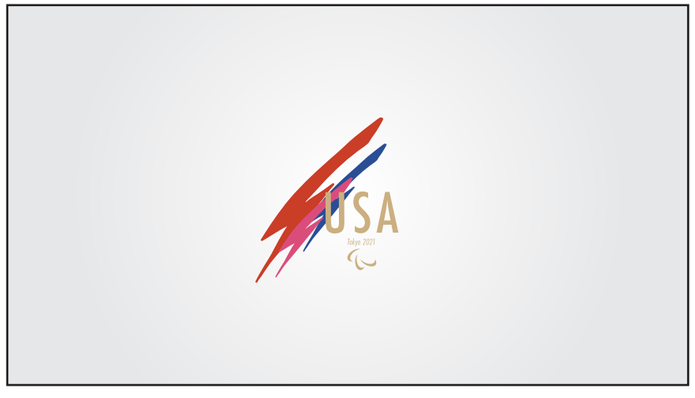
PUSH GLOVE BOX

First Impression, Storing Gloves for Keepsakes

Closed

Label with athlete name

Top



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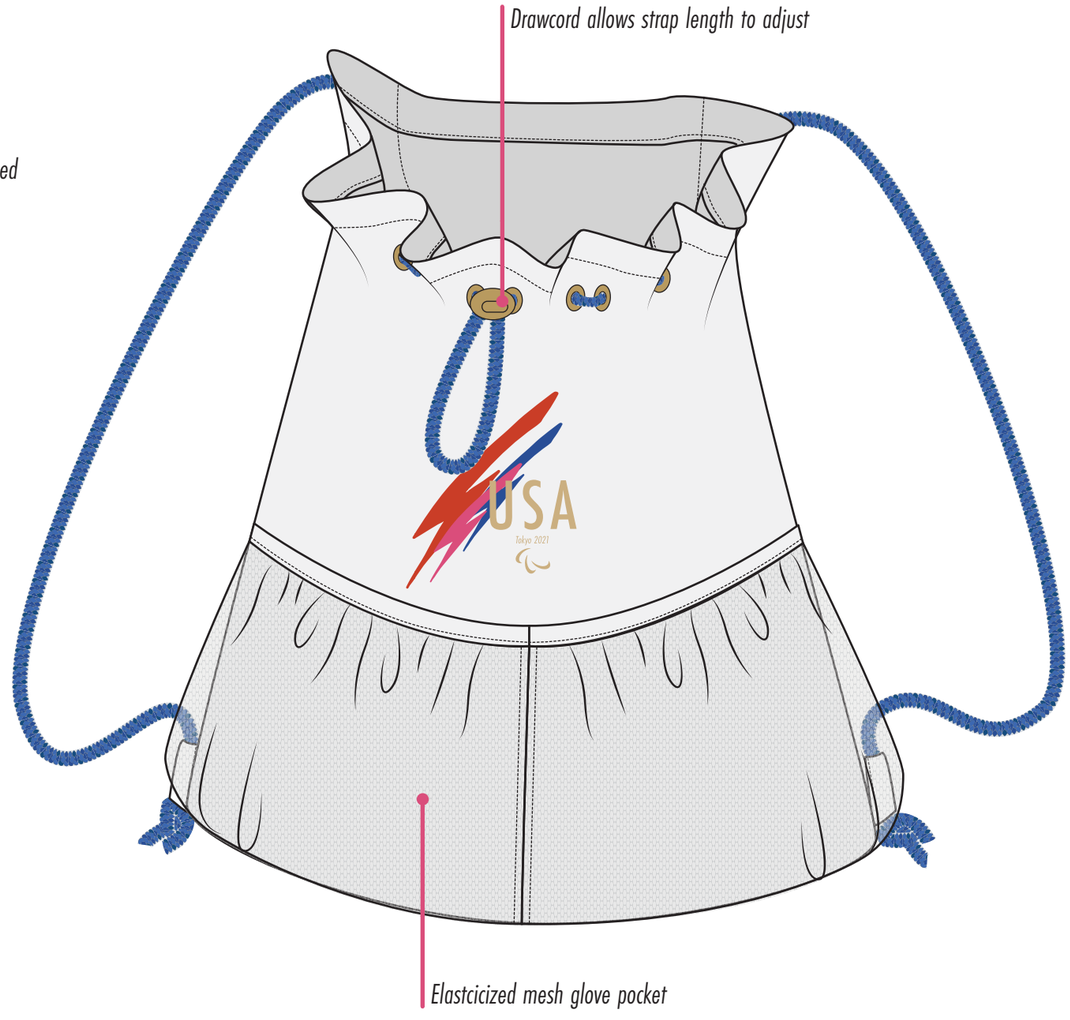
COMPETITION BAG

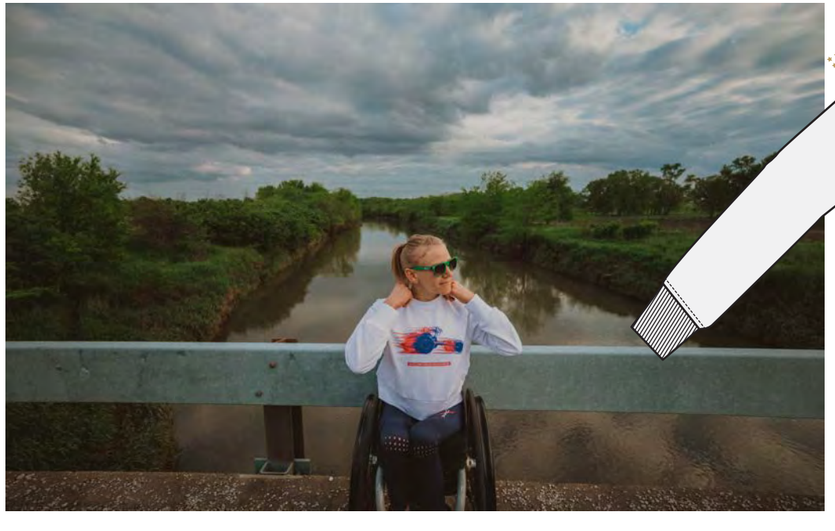
Functional

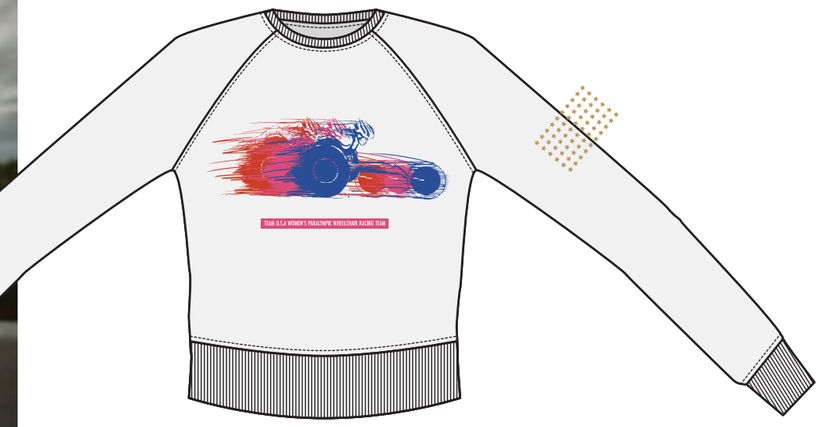


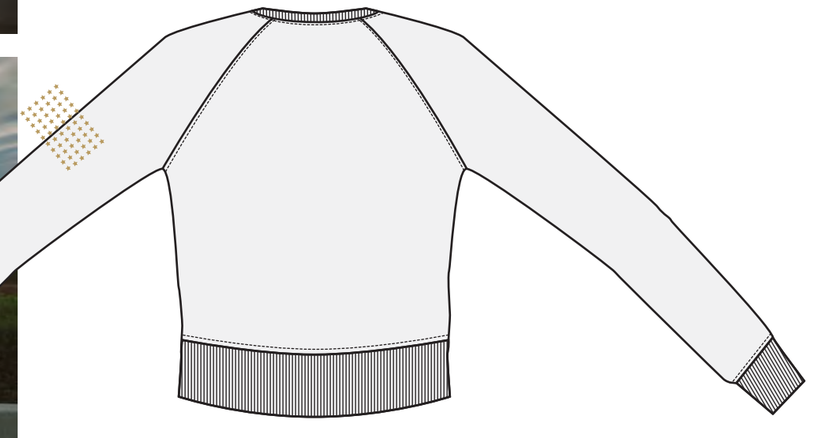
VELOX *SUPPLEMENTAL BRANDED PRODUCT*

CLASSIC CREW NECK SWEATSHIRT

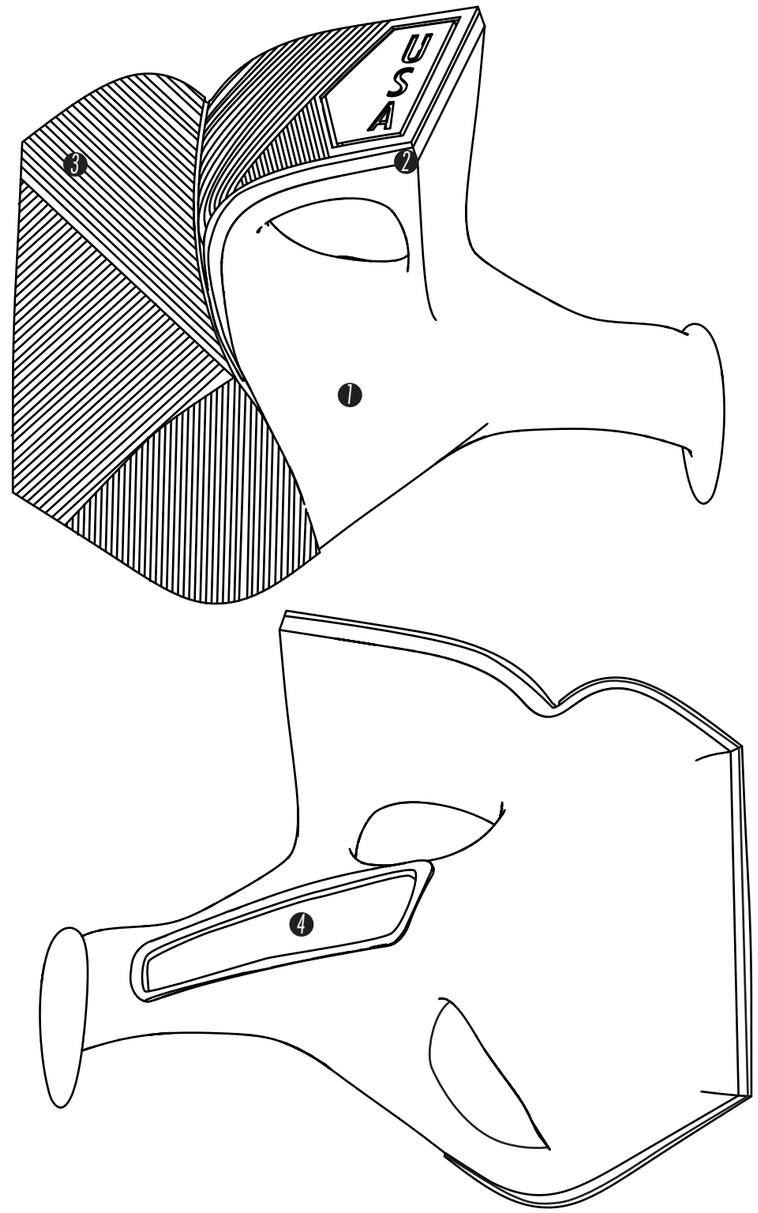
Recovery, Travel, Keepsake item



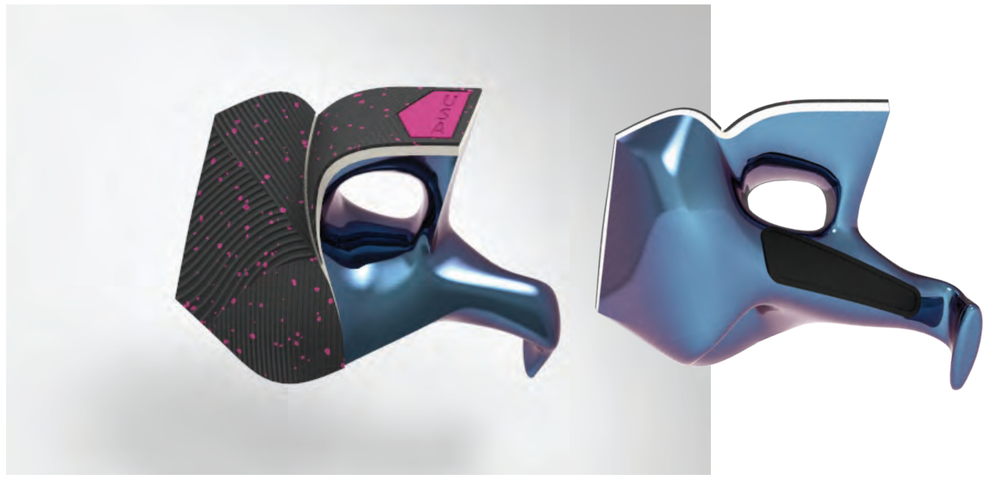




VELOX *PUSH GLOVE*

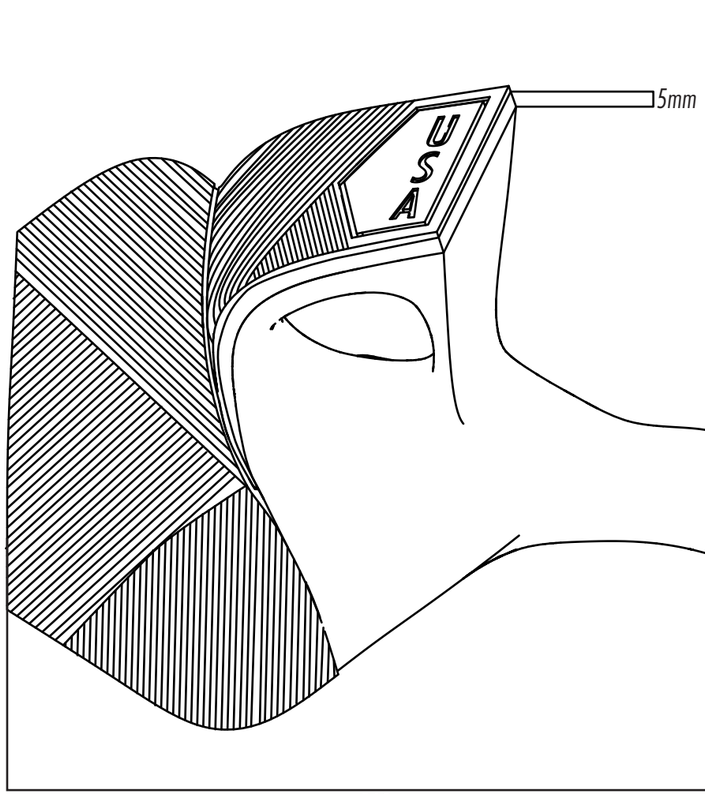


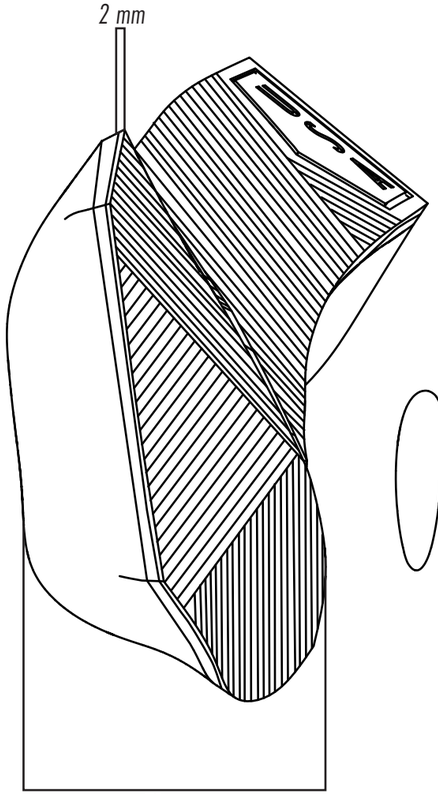
Sample Photos:

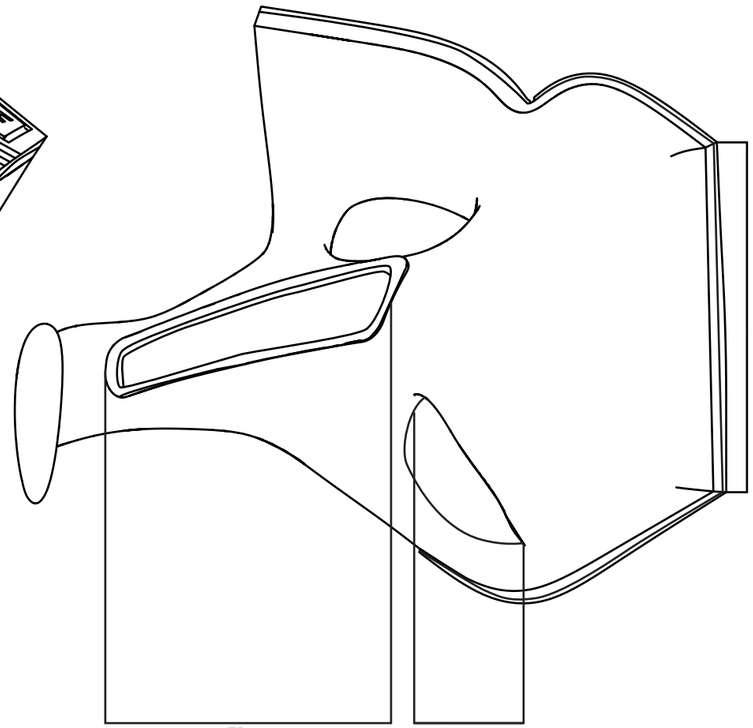


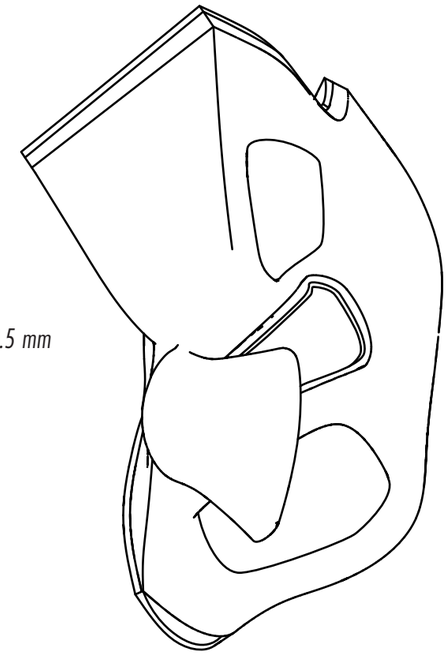
	Material	*Color*	*Construction/Finish*
1	*Carbon Fiber/Nylon Composite*	*Blue/Purple Iridescent*	*3Dd printed, shiny finish*
2	*EVA Foam*	*White*	*injection molded*
3	*Vibram MegaGrip Rubber*	*Black w/ pink speckles, pink*	*stamped flat, die-cut*
4	*Soft Rubber*	*Black*	*stamped flat, die-cut*

VELOX *PUSH GLOVE*

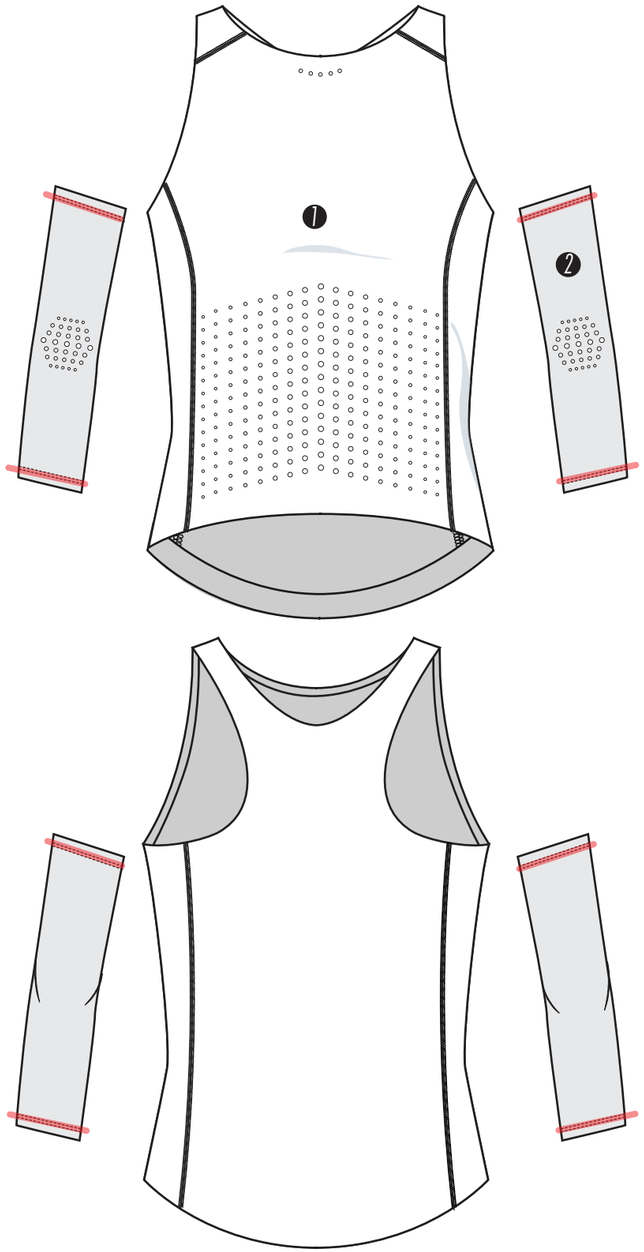








VELOX *RACING KIT SINGLET & ARM SLEEVES*



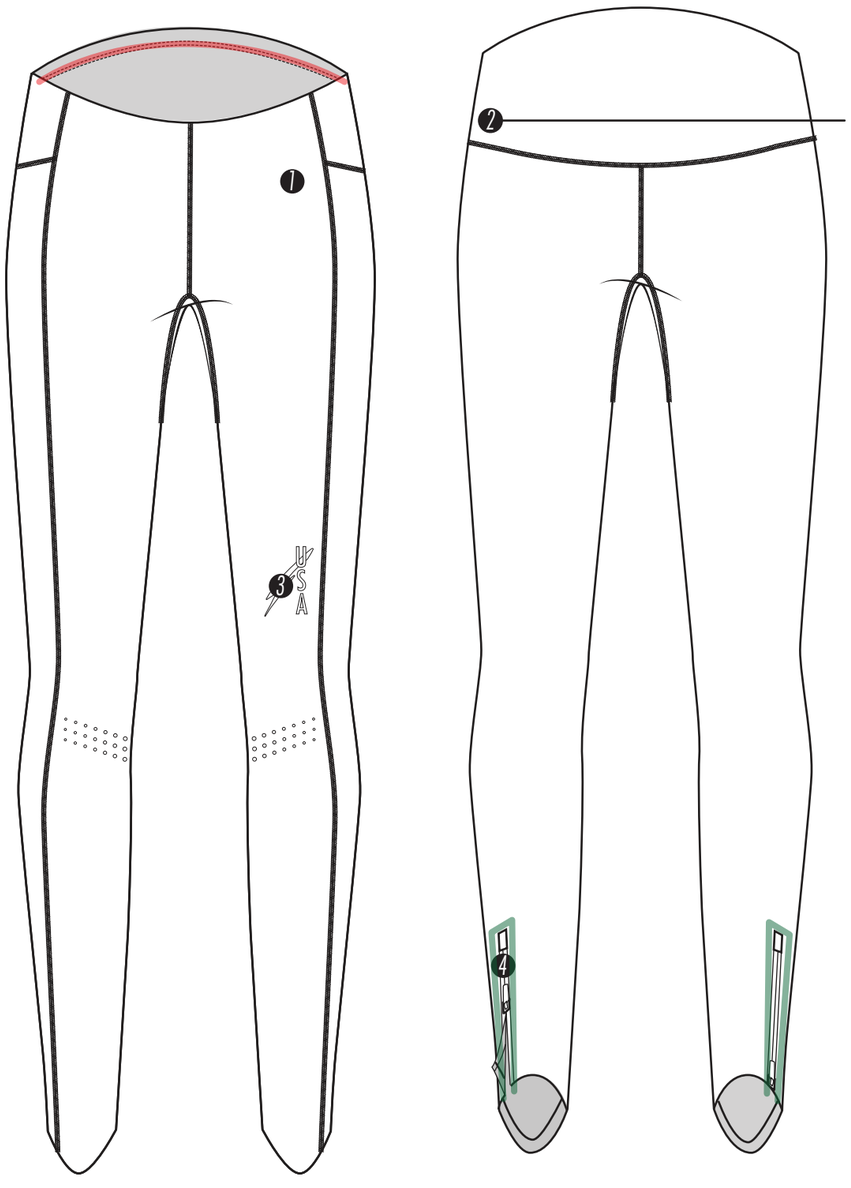
Sample Photos:

	Material	*Color*	*Finish*
1	*4-way stretch spandex/polyester*	*white*	*laser cut, sublimated print*
2	*4-way stretch spandex/polyester/kevlar*	*white*	*laser cut, sublimated print*

**All Seams Are #607 flat Seams Unless Otherwise Indicated*

#406 Bottom Coverstitch

VELOX *RACING KIT COMPETITION LEGGINGS*



Power Mesh folded & Stitched as interfacing

Sample Photos:

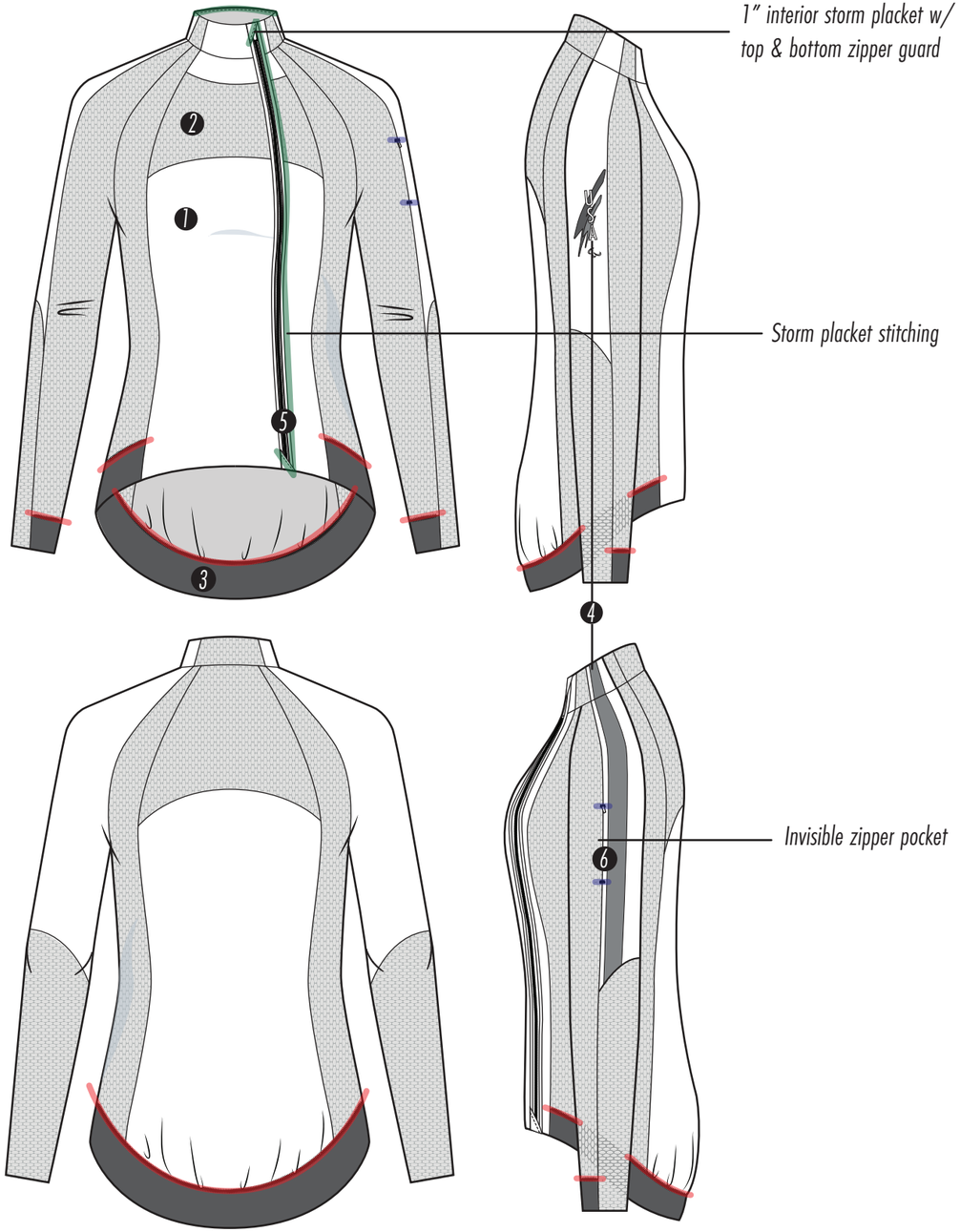
	Material	*Color*	*Finish*
1	*4-way stretch slick spandex/polyester*	*Navy Blue*	*laser cut*
2	*Power Mesh*	*Black*	*N/A*
3	*Stahls CAD Cut Heat Press*	*White, Red*	*CAD Cut*
4	*7" Exposed Metal Zipper w/Branded Locking Pull*	*Metallic Gold*	*Stamped Metal*

**All Seams Are 607 flat Seams Unless Otherwise Indicated*

#406 Bottom Coverstitch

#301 Lock Stitch

VELOX *WEATHERPROOF TRAINING KIT RAIN JACKET*



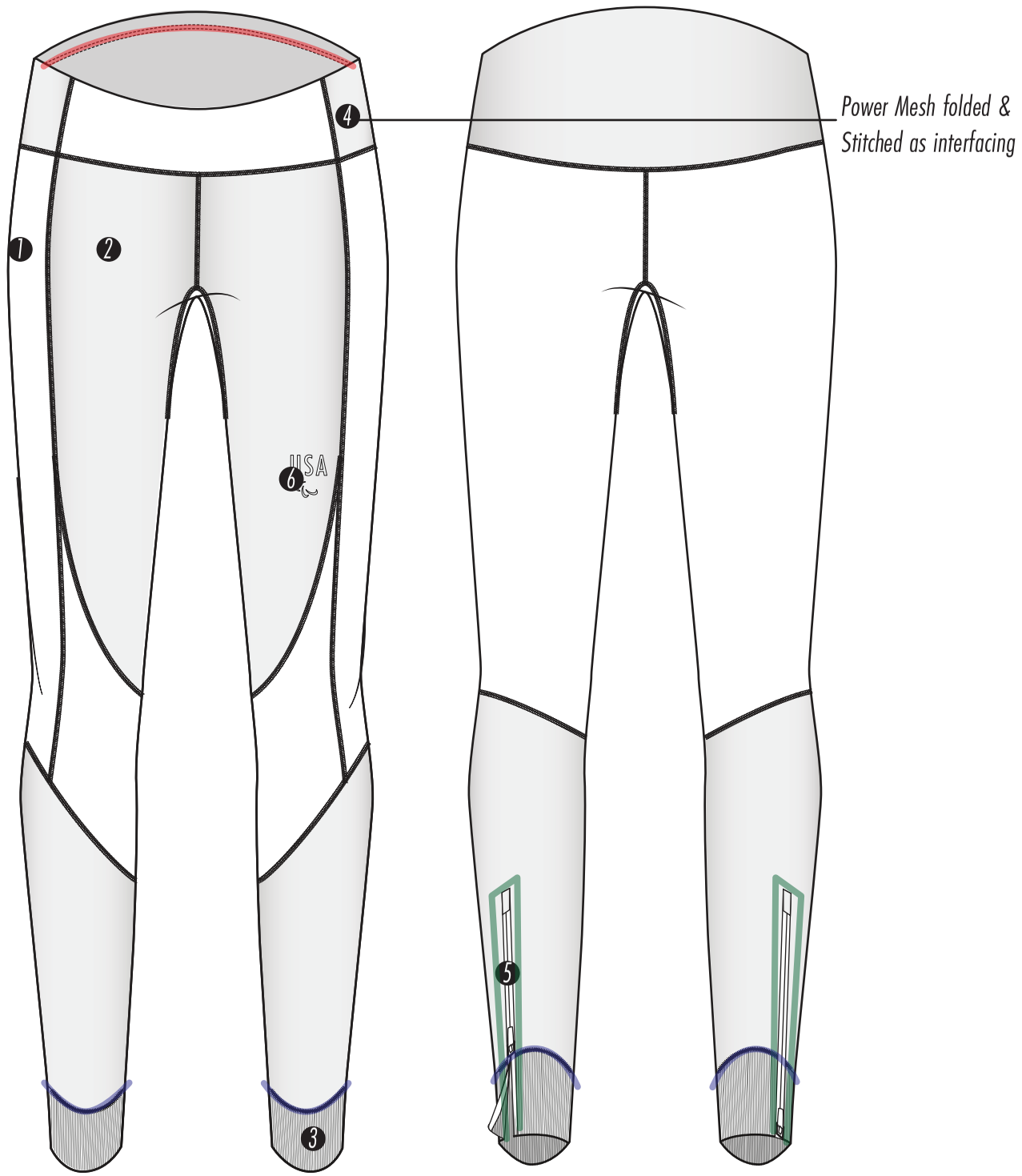
Sample Photos:

	Material	Color	Finish
1	Gore Tex™ Woven	Red	N/A
2	Gore Tex™ 2-Way Stretch	Red	N/A
3	Neoprene	Black	Laser Cut
4	Stahls CAD Cut Heat Press	Magenta, Blue, White	CAD Cut
5	____" Exposed Waterproof Zipper	Black	Branded Molded Rubber Pull
6	____" Invisible Zipper	Black	

*All Seams Are Seam Sealed #516 Safety Stitch Unless Otherwise Indicated

- #304 Zig Zag Stitch-Bar Tack
- #304 Zig Zag Stitch
- #301 Lock Stitch

VELOX *WEATHERPROOF TRAINING KIT TRAINING LEGGINGS*



Sample Photos:

	Material	Color	Finish
1	4-way stretch knit slick polyester/spandex	Black	N/A
2	Polyester/Spandex stretch woven	Black	Water/Wind Resistant
3	4-way stretch Polyester/Spandex Rib knit	Black	N/A
4	Power Mesh	Black	N/A
5	9" Exposed Zipper w/ locking branded molded rubber pull	Black	Branded Molded Rubber Pull
6	Stahls CAD Cut Heat Press	White	CAD Cut

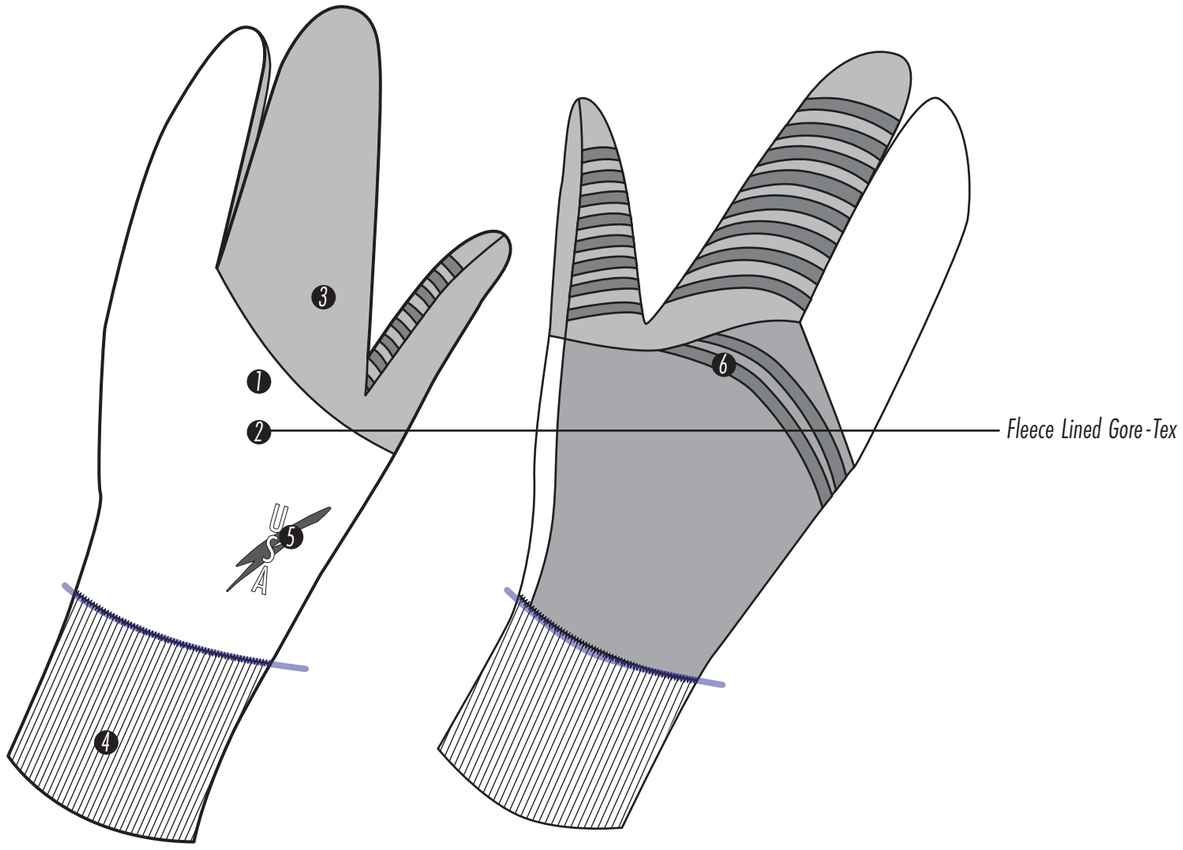
*All Seams Are 607 flat Seams Unless Otherwise Indicated

#301 Lock Stitch

#406 Bottom Coverstitch

#304 Zig Zag Stitch

VELOX *THERMAL MIT*



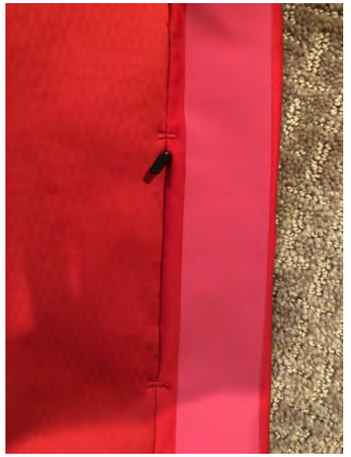
Sample Photos:

	Material	Color	Finish
1	Gore Tex™ Woven	Red	N/A
2	4-way stretch Moisture Wicking polyester/spandex fleece	Red	N/A
3	4-way stretch knit slick polyester/spandex	Black	N/A
4	4-way stretch Polyester/Spandex Rib knit	Black	N/A
5	Stahls CAD Cut Heat Press	White, Blue	CAD Cut
	Silicone	Black	Wet applied w/ Stencil

*All Seams Are #301 Lock Stitch Unless Otherwise Indicated

#304 Zig Zag Stitch

VELOX *COLLECTION MAKING*



VELOX *COLLECTION FINAL PROTOTYPES*

RACING KIT

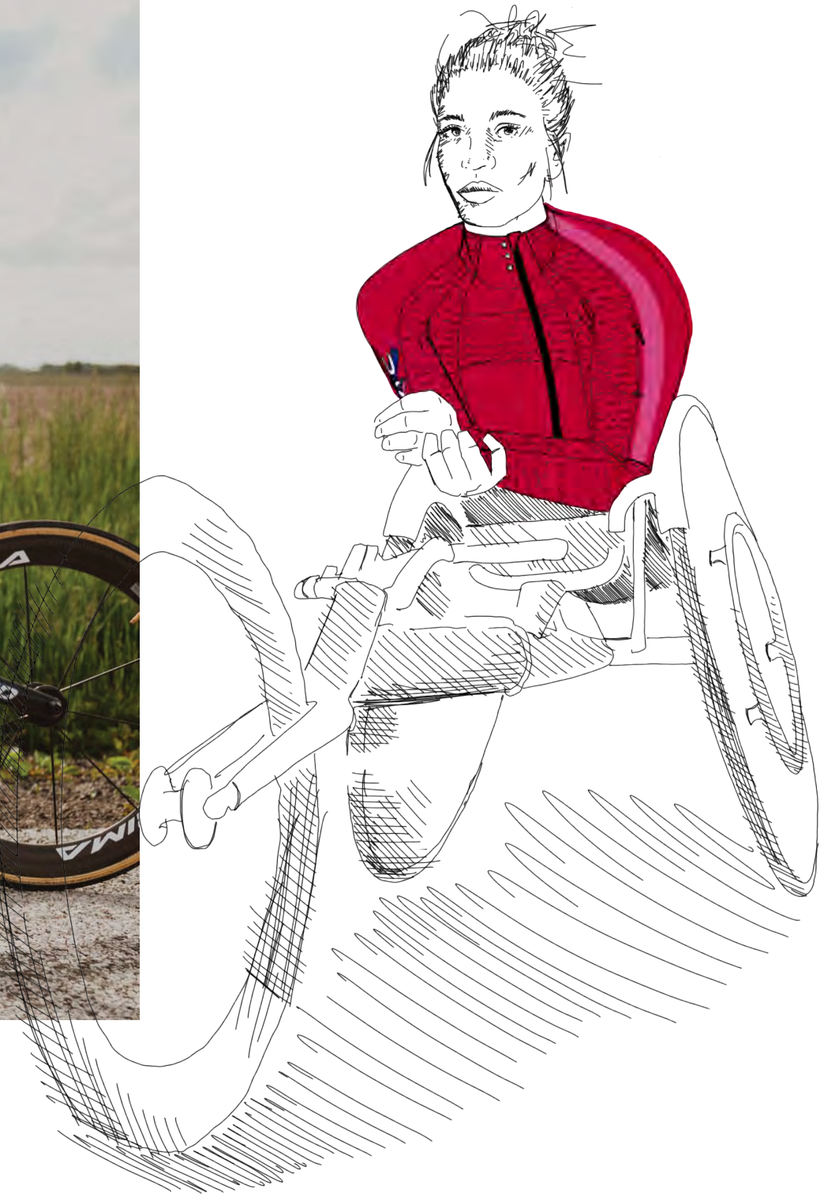
- _SINGLET
- _LEGGINGS
- _ARM SLEEVES

WEATHERPROOF KIT

- _JACKET
- _LEGGINGS
- _MITTS

PUSH GLOVE

VELOX *TEAM USA WEATHERPROOF TRAINING APPAREL*



VELOX *TEAM USA WEATHERPROOF TRAINING APPAREL*

ERGONOMIC & PERFROMANCE DRIVEN TRAINING APPAREL TO PROTECT RACERS FROM THE ELEMENTS

FITTED & ERGONOMIC SILHOUETTE

FITTED AROUND WAIST & HIP TO FIT INTO CHAIR.
LONGER IN BACK AND SHORTER IN FRONT

BODY MAPPED STRETCH PANELS

STRETCH PANELS AROUND CHEST & SHOULDERS TO ALLOW FULL MOBILITY AND A TIGHTER FIT ON THE BODY

GORE TEX™ FABRICS

BREATHABLE WEATHER PROTECTION TO KEEP ATHLETE DRY & COMFORTABLE

CONSIDERED STORAGE & MINIMAL DESIGN

NO FRONT POCKETS OR HOODS THAT COULD GET IN ATHLETES WAY.
CONSIDERED POCKETS TO ALLOW FOR STORAGE OF CARDS & KEYS THAT WON'T IMPEDE MOTIONS

VELOX *TEAM USA WEATHERPROOF TRAINING JACKET*

THE VELOX TRAINING JACKET ALLOWS FOR FULL RANGE OF MOTION WHILE PROVIDING BREATHABLE WEATHER PROTECTION. A DISCREET ARM POCKET ALLOWS FOR SMALL ITEM STORAGE WITHOUT GETTING IN THE WAY.

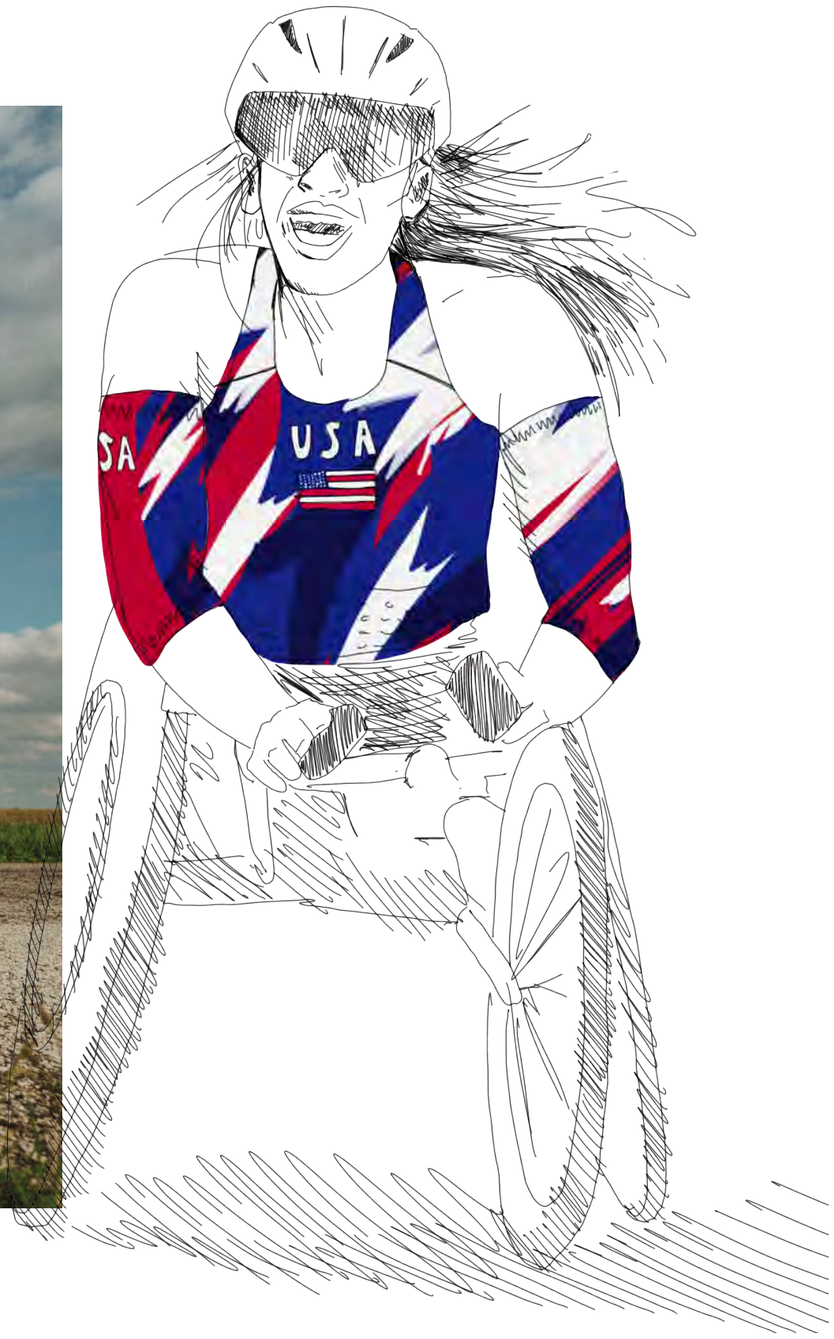
VELOX *TEAM USA WEATHERPROOF TRAINING LEGGINGS*

THE VELOX TRAINING LEGGINGS PROVIDE A SMOOTH SILHOUETTE WITH WEATHER PROTECTION WHERE IT'S NEEDED. ANKLE ZIPPERS ALLOW FOR EASY ON & OFF, AS WELL AS A TIGHT FIT.

VELOX *TEAM USA WEATHERPROOF LOBSTER MITT*

THE VELOX LOBSTER MITT IS DESIGNED TO INTERACT WITH A TWO FINGERED RIGID PUSH GLOVE, BALANCING THERMAL PROTECTION WITH A TIGHT FIT TO KEEP ATHLETE'S HANDS WARM & DRY IN CHILLY CONDITIONS.

VELOX *TEAM USA RACING KIT*



VELOX *TEAM USA RACING KIT*

DESIGNED FOR THE ERGONOMIC, THERMOREGULATORY, & PROTECTIVE NEEDS OF WOMEN'S WHEELCHAIR RACERS

BODY MAPPED VENTILATION

LASER CUT VENTILATION FOCUSED ON THE STOMACH WHERE SWEAT COLLECTS MOST

ERGONOMIC SILHOUETTE

HIGHER RISE & LONGER LENGTH ALONG THE BACK LINE OF THE BODY AND SHORTER IN THE FRONT TO ACCOMODATE THE ATHLETE'S FORWARD LEAN. FITTED TO THE ANTHROPOMETRY OF WHEELCHAIR RACERS

MINIMAL EDGES

LOW PROFILE LASER CUT & GLUED EDGES TO MINIMIZE CHAFING RISK

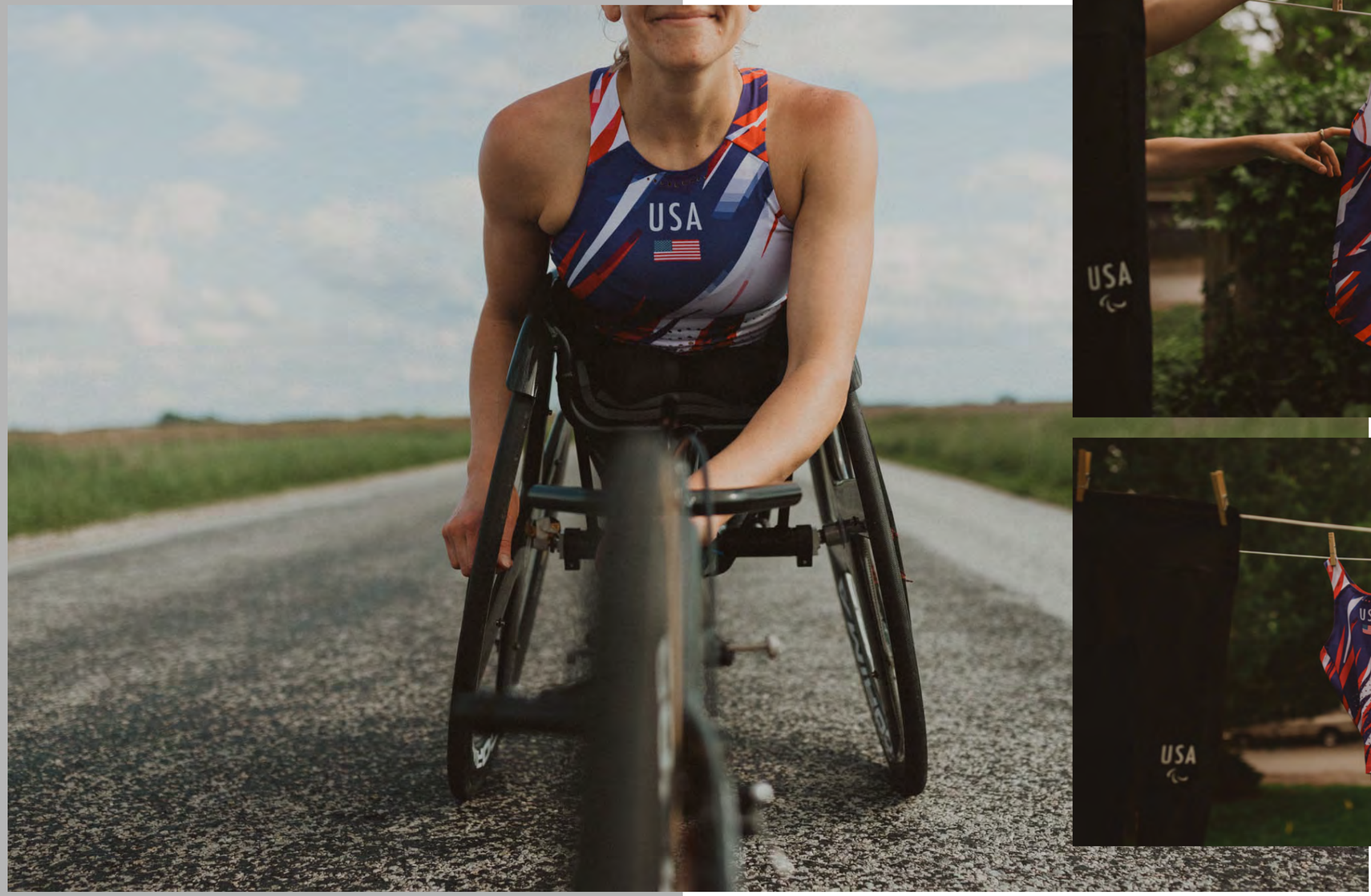
HIGH COVERAGE & PROTECTIVE DESIGN DETAILS

HIGH NECKLINE, LONG TIGHTS, AND KEVLAR BLENDED ARM SLEEVES TO PROTECT RACERS FROM RACING CHAIR AND KEEP ATHLETE COMFORTABLE

POSITIONING INFORMED GRAPHICS

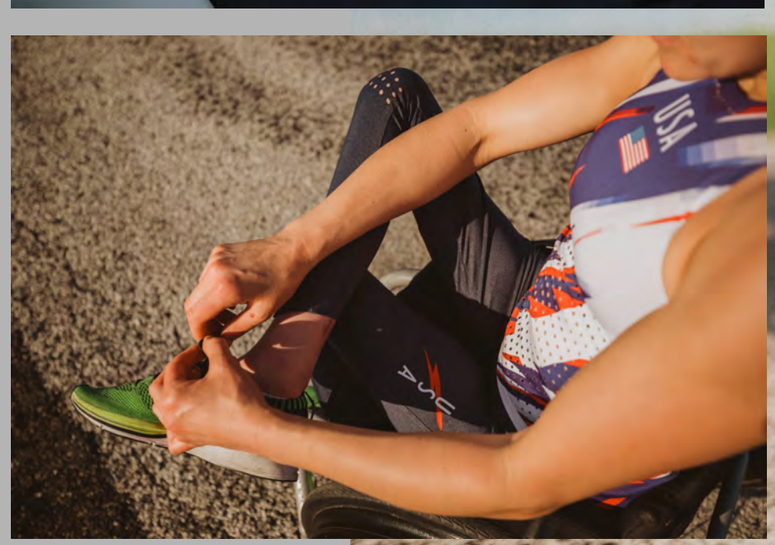
GRAPHICS VISIBLE BY CAMERA WHILE ATHLETE IS COMPETING, CONCENTRATED ON BACK, UPPER CHEST, & ARMS

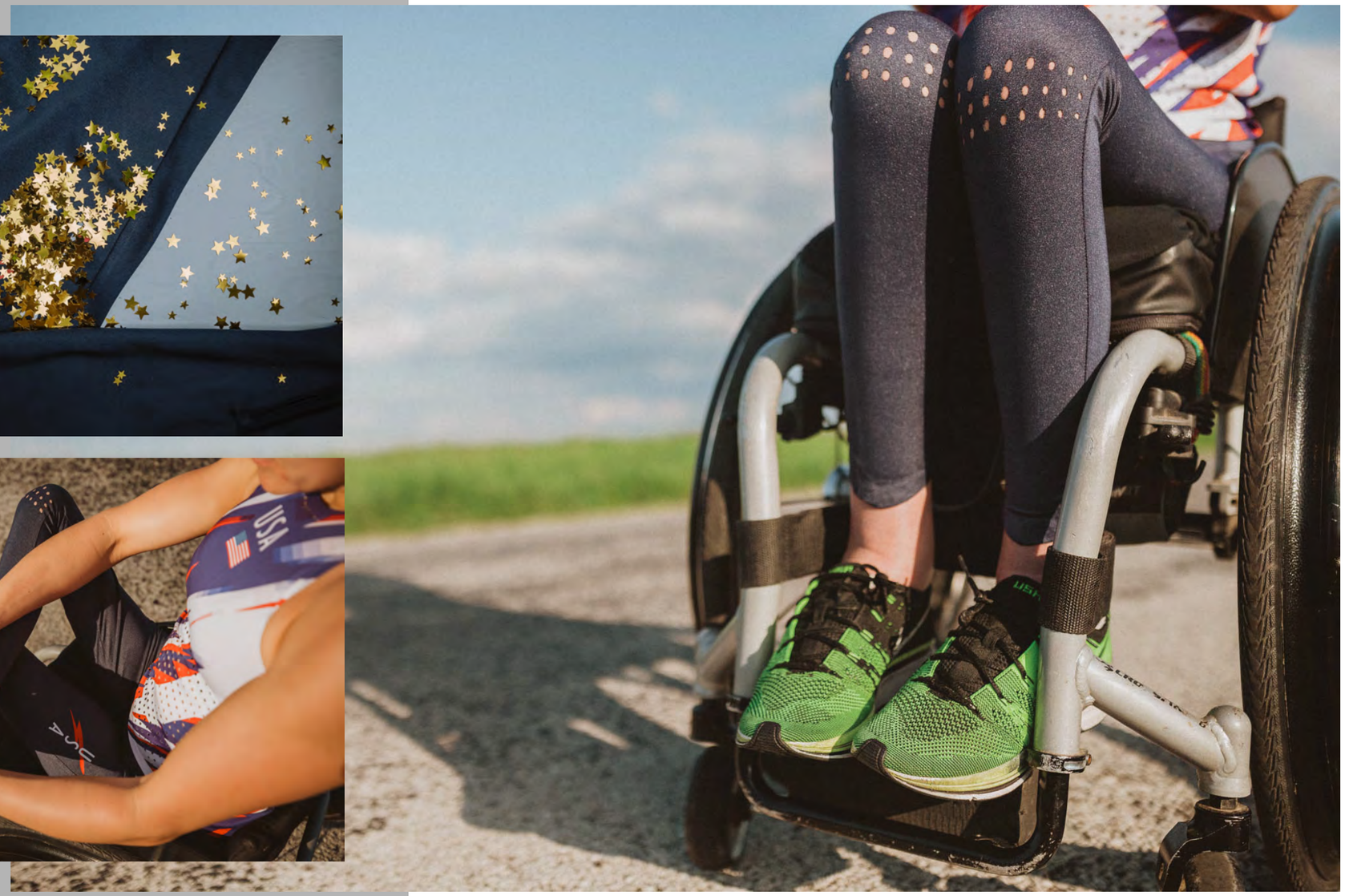
VELOX *TEAM USA RACING SINGLET*



MINIMAL EDGES & BODYMAPPED VENTILATION MEAN ATHLETES STAY MORE COMFORTABLE THROUGHT THEIR RACE, ALLOWING THEM TO FOCUS ON PERFORMANCE. NATIONAL GRAPHICS ALONG THE BACK MAKE ATHLETES IDENTIFIABLE WHILE COMPETING.

VELOX *TEAM USA RACING LEGGINGS*





ANKLE ZIPPERS & SLICK FABRICS MAKE DONNING AND GETTING INTO THE CHAIR EASY. AN ERGONOMIC SILHOUETTE AND MINIMAL VENTILATION ALLOW ATHLETES TO STAY COMFORTABLE WHILE COMPETING.

VELOX *TEAM USA RACING ARM SLEEVE*

THE VELOX RACING ARM SLEEVE PROVIDES PROTECTION THROUGH A UNIQUE KEVLAR BLENDED KNIT WHILE VENTILATION & A 3/4 LENGTH MEAN ATHLETES STAY COOL.

VELOX *TEAM USA PUSH GLOVE*

PUSH GLOVES DESIGNED TO PROTECT THE HAND & MINIMIZE WRIST STRAIN WITHOUT IMPACTING PERFORMANCE

FOAM PROTECTED HITTING SURFACE

MINIMIZE IMPACT INJURY AND ALLOW FOR A MORE SECURE GRIP ON THE PUSH RIM

TREAD PATTERN ENHANCED RUBBER

ENHANCE TRACTION IN HUMID CONDITIONS & LEND A PERFORMANCE AESTHETIC

SLEEK & FLUID GEOMETRY

PROVIDE A PERFORMANCE AESTHETIC TO THE PIECE & ELEVATE THE PERCIEVED INTEGRITY OF THE GLOVE

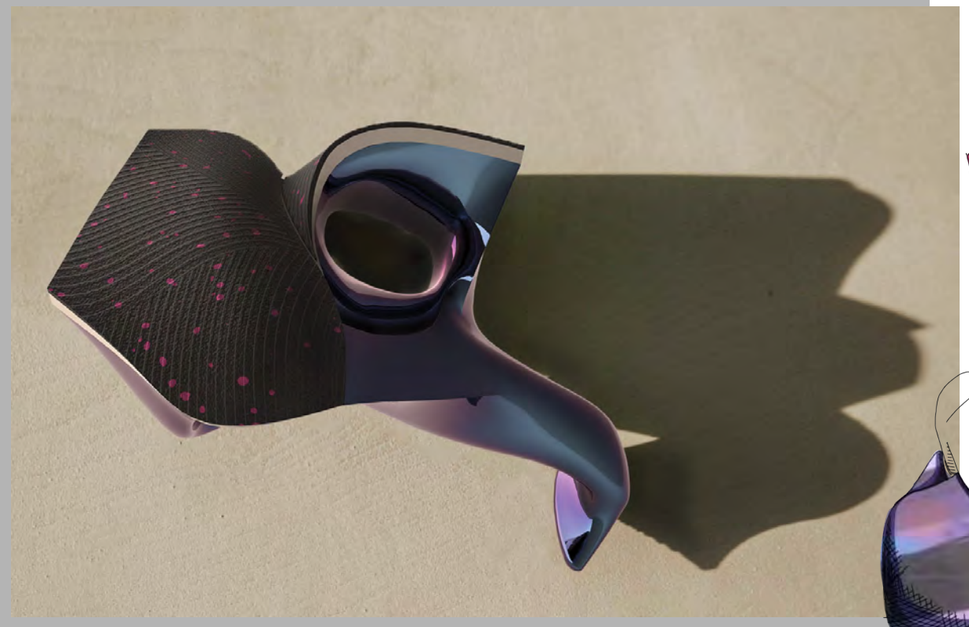
FLARED THUMB SHAPE

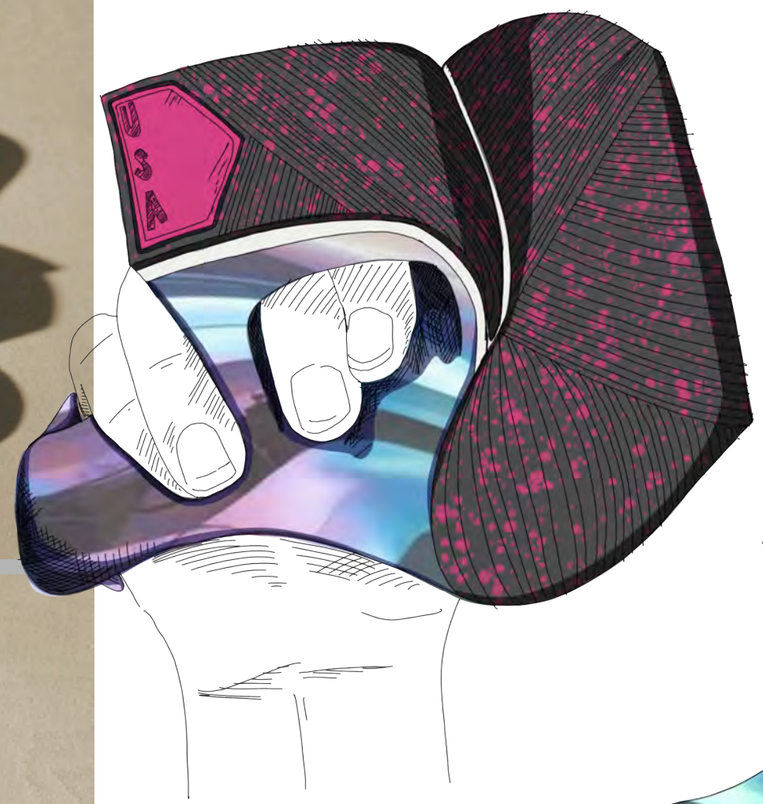
LESSEN FOREARM PRONATION AT THE BACK OF THE RACING STROKE TO MINIMIZE ULNAR DEVIATION, KEEP THE WRIST CLOSER TO NEUTRAL POSITIONING, AND MINIMIZE INJURY RISK OVER TIME

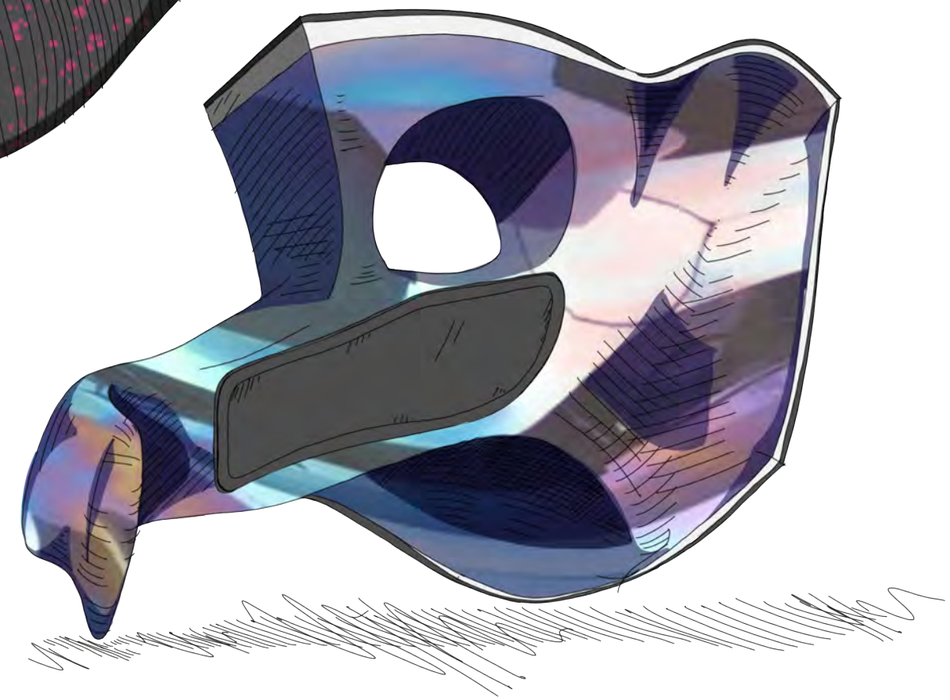
METALLIC FINISHES

FLICKER IN SUNLIGHT & STADIUM LIGHTING TO PROVIDE VISUAL INTEREST AS THE ATHLETE MOVES

VELOX *TEAM USA PUSH GLOVE*





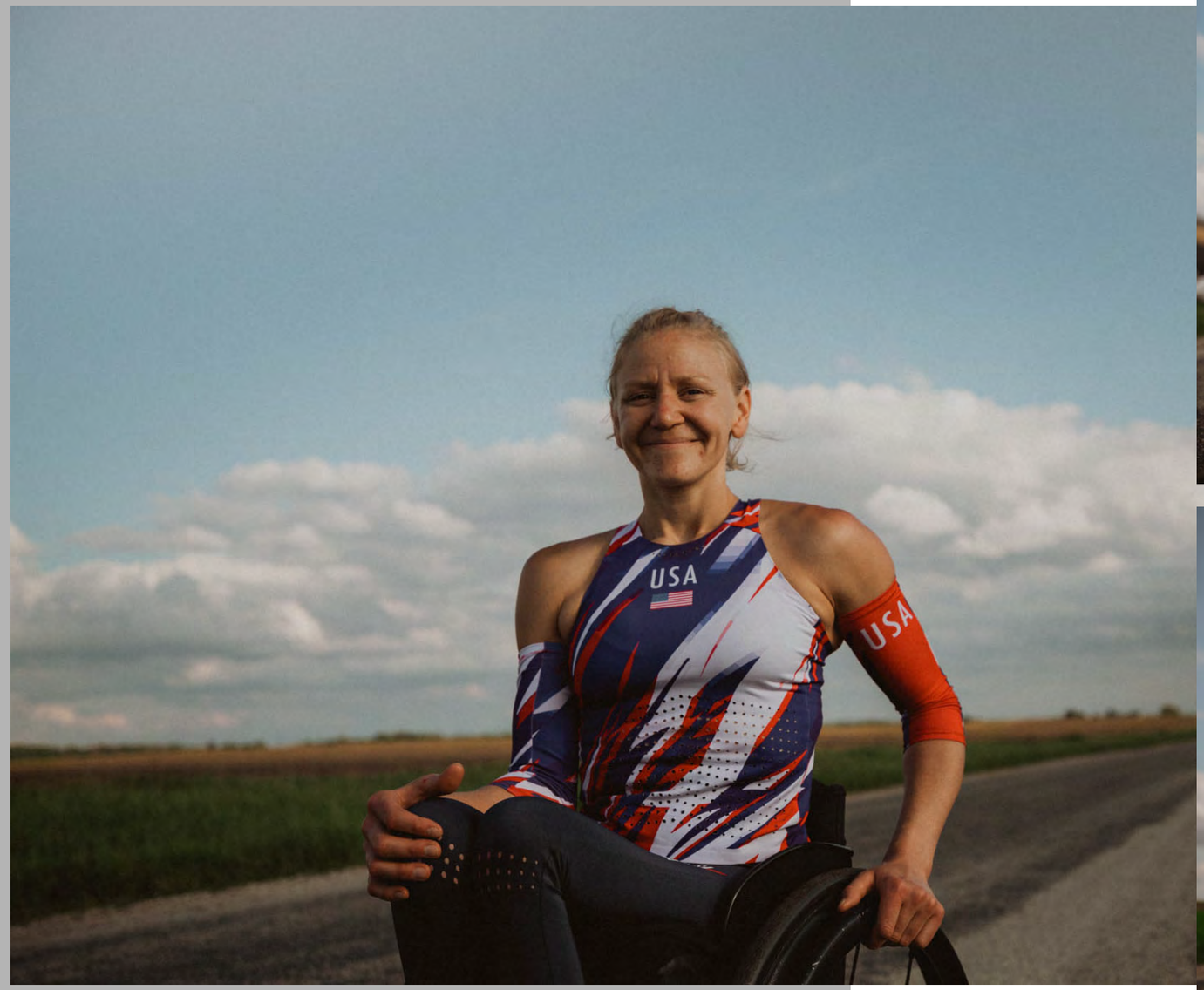


VELOX *PHOTOS*

VELOX *PHOTOS*

VELOX *PHOTOS*

VELOX *PHOTOS*



VELOX *ACKNOWLEDGMENTS*

FIRST I'D LIKE TO THANK SUSANNAH SCARONI, ARIELLE RAUSIN, YEN HOANG, AND ADAM BLEAKNEY FOR THEIR INVALUABLE INPUT AND INVESTMENT IN THE PROJECT—YOU ALL TRULY MADE THE VELOX PROJECT COME ALIVE.

SECONDLY, I NEED TO THANK MY UO SPORTS PRODUCT DESIGN FAMILY FOR THEIR CONTINUED SUPORT THROUGHOUT THIS STRANGE TIME AND TO SUSAN FOR HER ENCOURAGEMENT AND BELIEF IN MY ABILITY TO PERSEVERE.

FINALLY, I'D LIKE TO THANK GORE PRODUCTS FOR LENDING ME BEAUTIFUL TECHNICAL FABRICS FOR THE PROJECT, WSI SPORTS OF MINNESOTA FOR ALLOWING ME TO USE THEIR SUBLIMATION & LASER CUTTING RESOURCES WHILE THE STUDIO WAS CLOSED & LAYLA ALAZAWY FOR THE BEAUTIFUL PRODUCT PHOTOGRAPHY

VELOX KIT & GOLD MEDAL GLOVES

TOKYO 2020 PARALYMPIC UNIFORM, WARM UP APPAREL, & GLOVES FOR WOMEN'S WHEELCHAIR RACING

SARAH KLECKER • SPORTS PRODUCT DESIGN THESIS RESEARCH • WINTER 2020

WHY?

STIGMA STILL EXISTS THAT ASSOCIATES WHEELCHAIRS WITH TRAGEDY & ILLNESS, AND MANY SPORT SPACES & PRODUCTS ARE STILL EXCLUSINOARY TO ATHLETES IN WHEELCHAIRS. BY DESIGNING FOR THE ELITE WHEELCHAIR RACING ATHLETE, WE OPEN THE DOOR FOR FURTHER ADAPTIVE PRODUCT TAILORED TO THE NEEDS OF WHEELCHAIR USERS AND CHANGE THE LIMITED PERCEPTION OF WHAT IT LOOKS LIKE TO BE AN ATHLETE

WHEELCHAIR TRACK & MARATHON RACING

THE RACING OF WHEELCHAIRS IN TRACK & FIELD AND ROAD RACES, OPEN TO ATHLETES WITH QUALIFYING DISABILITIES

UNLIKE MARATHON RUNNERS, WHEELCHAIR RACING ATHLETES WILL OFTEN RACE MANY TRACK EVENTS RANGING FROM SPRINTS TO DISTANCE

DISABILITY CLASSIFICATIONS

T52: ATHLETES USE SHOULDER, ELBOW, AND WRIST MUSCLES FOR WHEELCHAIR PROPULSION, POOR TO FULL MUSCLE POWER IN THE FINGERS, TYPICALLY TRUNK MUSCLE FUNCTION IS ABSENT

T53: ATHLETES TYPICALLY HAVE FULL MUSCLE FUNCTION IN THE ARMS, BUT NO ABDOMINAL OR LOWER SPINAL CORD MUSCLE ACTIVITY

T54: ATHLETES HAVE FULL MUSCLE FUNCTION IN THE ARMS, SOME TO FULL MUSCLE POWER IN THE TRUNK, AND MAY HAVE SOME MUSCLE FUNCTION IN THE LEGS

TOKYO 2020 PARALYMPIC WHEELCHAIR MARATHON

SEPTEMBER 6TH, 2020, 6:30 AM

78°F-95°F & 73%-75% HUMIDITY

26.2 MILES THROUGH JAPAN'S CAPITOL WITH UPHILL FINISH

TEAM USA WOMEN'S MARATHON ATHLETES: TATYANA MCFADDEN & SUSANNAH SCARONI

RACING UP TO 20 MPH

CURRENT TEAM USA UNIFORM & APPAREL

DEVELOPED FOR THE NEEDS OF STANDING TRACK ATHLETES

RIO UNIFORMS INCLUDED RUBBERY “AEROBLADES” MEANT TO AID RUNNER AERODYNAMICS, DID NOTHING FOR WHEELCHAIR RACERS

DOESN’T CONSIDER ANTHROPOMETRY OF WHEELCHAIR ATHLETES (I.E. OVERDEVELOPED ARMS/SHOULDERS, ATROPHIED LEG MUSCLES)

WARM UPS INCLUDE DETAILS UNUSABLE TO WHEELCHAIR RACING ATHLETES LIKE HOODS AND POCKETS

“THE TIGHTS HAD THESE LITTLE RUBBERY THINGS. THEY LOOKED COOL BUT WE COULDN’T GET INTO OUR CHAIRS WITH THEM”

YEN HOANG, 2016 PARALYMPIC WHEELCHAIR RACER

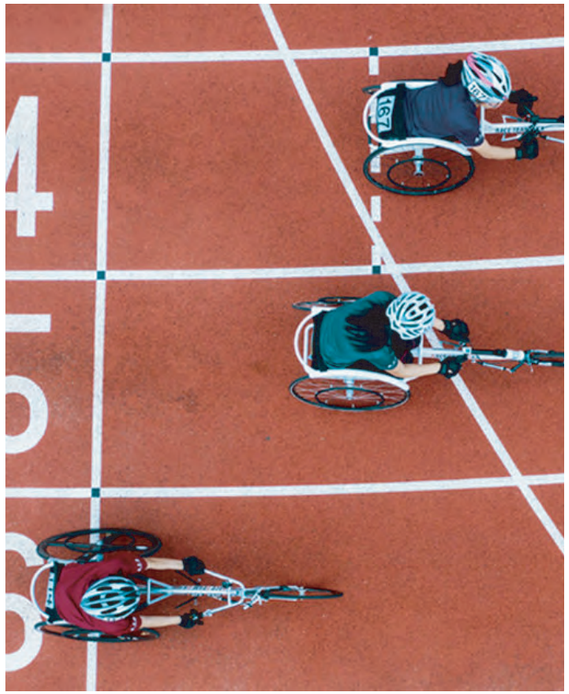
APPAREL AREAS OF CONCERN

ERGONOMICS & FIT

OVER DEVELOPED ARMS & ATROPHIED LEGS MAKE FIT HARD

UNIQUE WORKING POSITION REQUIRES LONGER BACK LENGTH & SHORTER FRONT

SILHOUETTES NEED TO BE VERY FITTED TO STAY OUT OF THE CHAIR/STRAPS



GRAPHIC PLACEMENT

TRADITIONAL CENTER FRONT NATIONAL IDENTIFIERS AREN'T VISIBLE WHILE ATHLETE IS COMPETING

ARMS AREN'T UTILIZED AS A VEHICLE FOR BRANDING

CONSIDER TRACK CURVES & CAMERA ANGLES IN PLACEMENT

CHAFING & IRRITATION

MISSED STROKES & RUBBING AGAINST FENDERS CAN CAUSE INTENSE CHAFING ON INNER ARMS

ATHLETES WILL WEAR PADDING OR SLEEVES FOR PROTECTION

LOWER BODY CHAFING CAN BE VERY DANGEROUS IN ATHLETES WITHOUT SENSATION

APPAREL AREAS OF CONCERN

HEAT/SWEAT

BODY POSITIONING CAUSES SWEAT BUILDUP ON THE STOMACH AND THIGHS OF THE ATHLETE

ATHLETES TYPICALLY WEAR HIGHER COVERAGE CLOTHING TO PROTECT FROM CHAIR, NOT IDEAL FOR HOTTER TEMPS

COLD/WEATHER

ATHLETES HAVE DIFFICULTY LAYERING APPAREL IN THEIR CHAIRS SINCE THE SEAT IS SO TIGHT

LAYERED APPAREL CAN IMPEDE SHOULDER & ARM MOBILITY

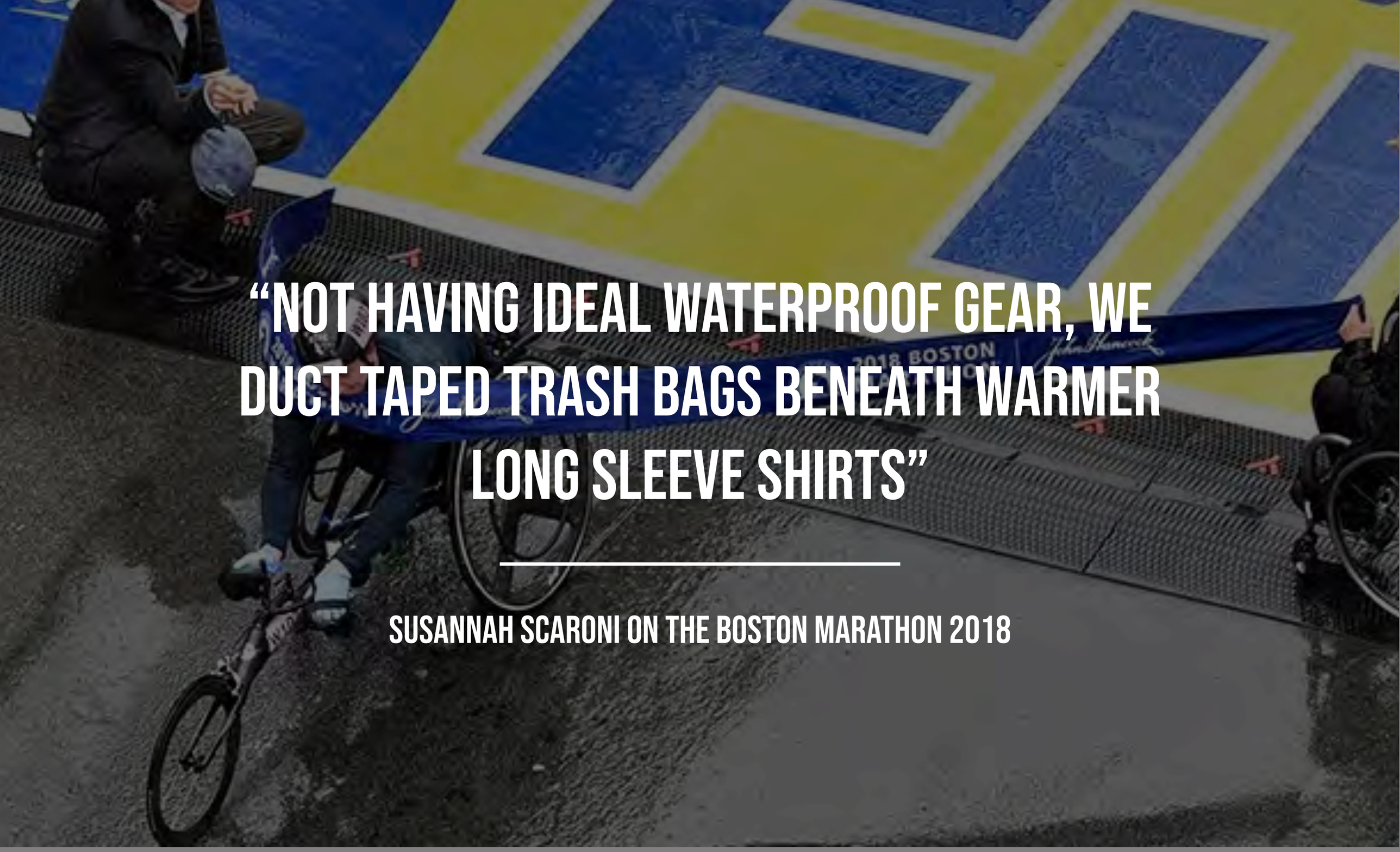
JACKETS OFTEN INCLUDE UNUSABLE DETAILS WHICH ADD BULK

DURABILITY & WEAR

STRESS POINTS ARE DIFFERENT THAN STANDING ATHLETES

RIPPER SHOULDER SEAMS, HOLES IN BUMS OF LEGGINGS FROM FRICTION

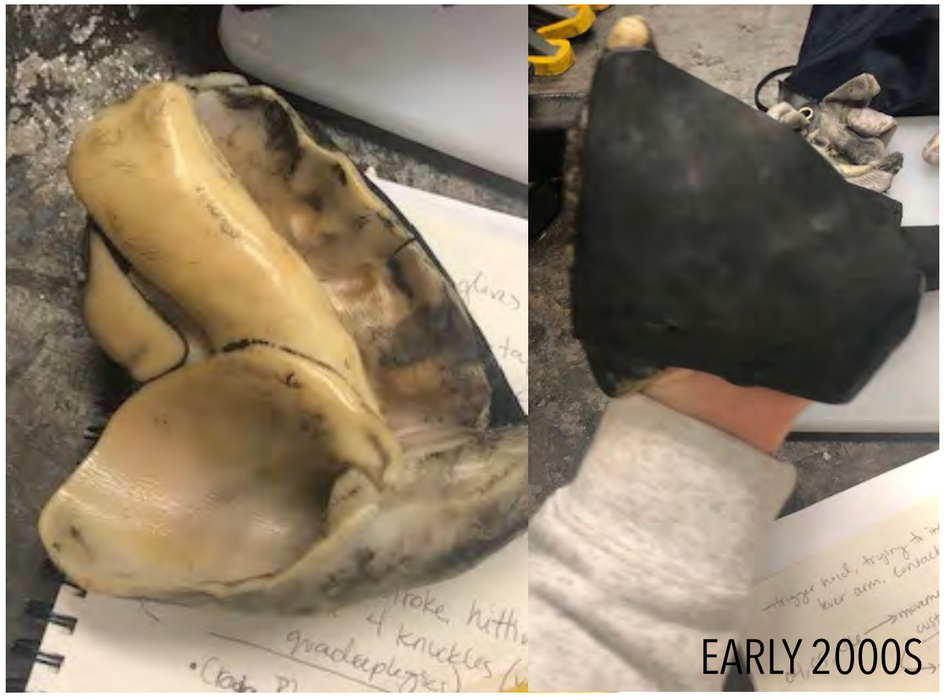
RIPS & SCUFFS ON SLEEVES FROM CHAIR FENDERS



“NOT HAVING IDEAL WATERPROOF GEAR, WE DUCT TAPED TRASH BAGS BENEATH WARMER LONG SLEEVE SHIRTS”

SUSANNAH SCARONI ON THE BOSTON MARATHON 2018

HISTORY OF WHEELCHAIR RACING GLOVES



MODERN WHEELCHAIR RACING GLOVES

3D PRINTED PLA PLASTIC RACING GLOVES

HONEYCOMB SHAPED INFILL TO MAKE GLOVES LIGHTER WEIGHT (~25% FILL)

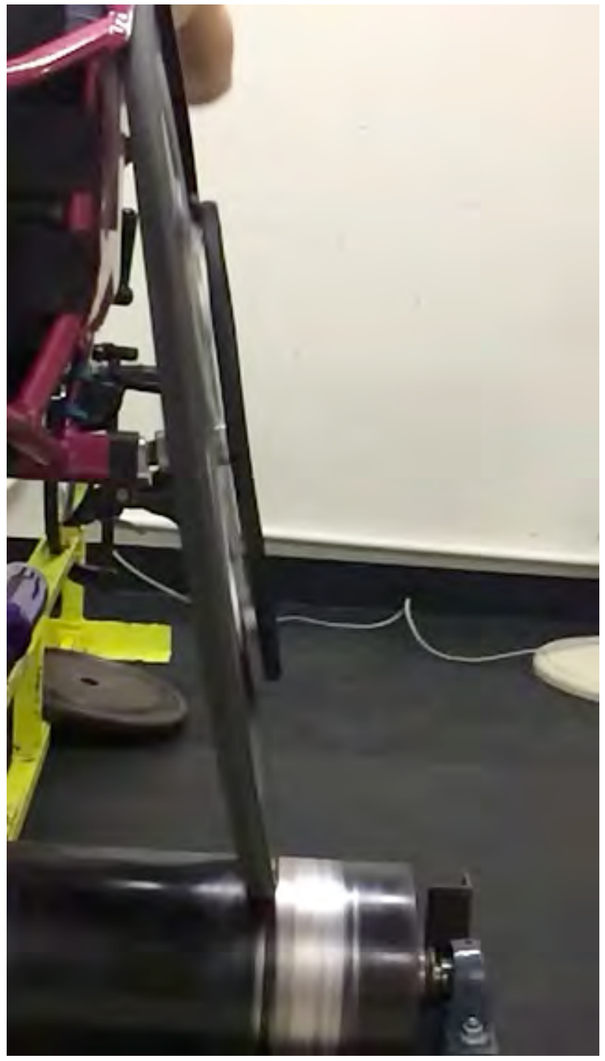
GLUED RUBBER FOR TRACTION

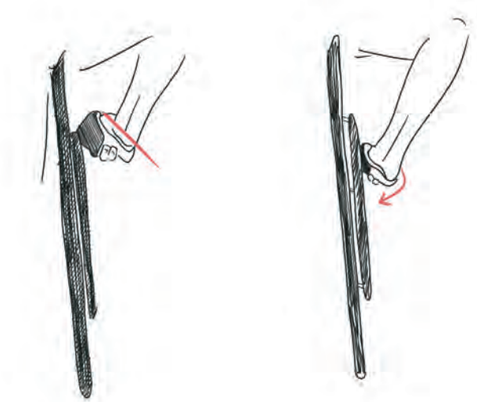
MODIFIED WITH SANDPAPER OR PINE TAR FOR GRIP IN WET OR HUMID CONDITIONS

CAN INCLUDE ELASTIC HAND STRAP

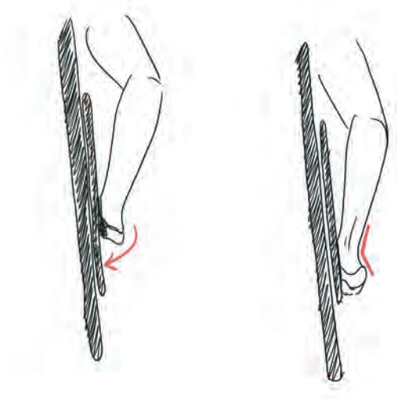
FLAT VS. GROOVED GLOVE GREATLY AFFECTS STROKE BIOMECHANICS

ARM & WRIST BIOMECHANICS

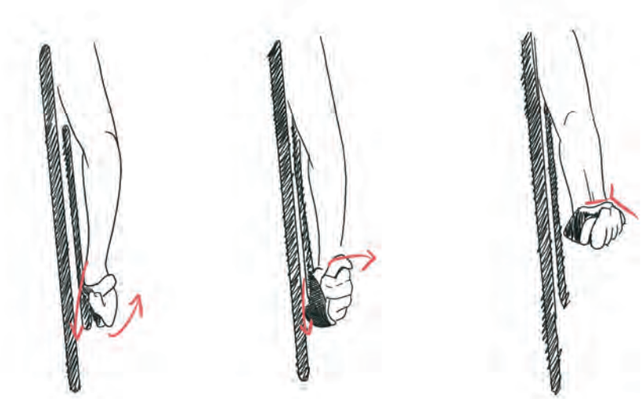




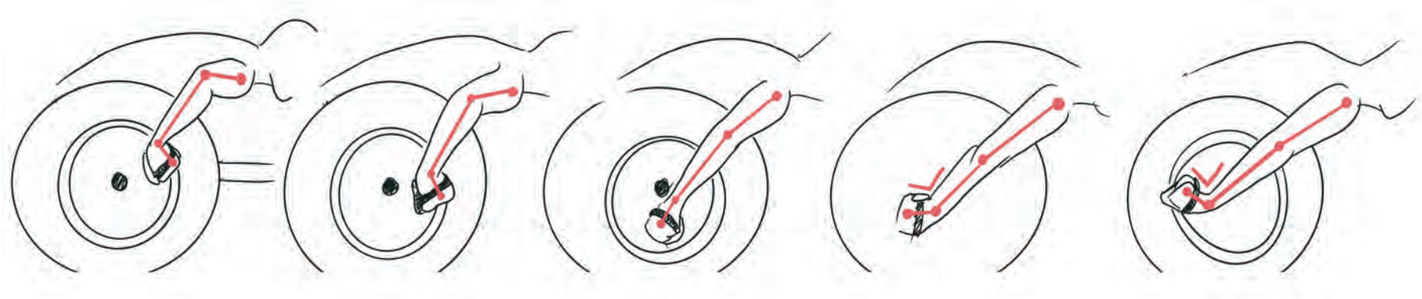
INITIAL COTACT MADE IN GROOVE OF THUMB & FIRST 2 FINGERS, PINKY POINTED OUTWARD



PINKY ROLES INWARD AS HAND DRIVES DOWNWARD. WRIST MOVES INTO NEUTRAL POSITION. CONTACT POINT IS AT BASE OF THUMB.

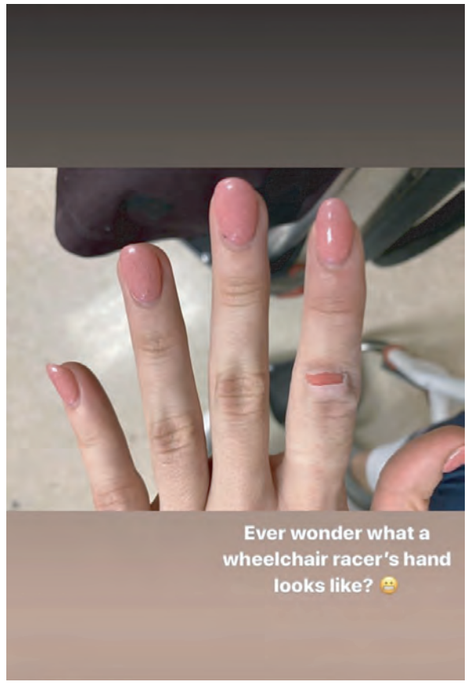


FOREARM PRONATES INWARD, PINKY ROLES OUT AS THUMB DRIVES DOWN. WRIST IS IN FLEXIONWITH PALM FACING UP AT RELEASE



PINKY ROLES INWARD AS HAND DRIVES DOWNWARD. WRIST MOVES INTO NEUTRAL POSITION. CONTACT POINT IS AT BASE OF THUMB.

HAND & WRIST INJURY



REPETITIVE FORCEFUL DYNAMIC WRIST MOVEMENTS CAN LEAD TO WRIST TENDINITIS OVER TIME

LACK OF PROTECTION ON THE HAND CAN LEAD TO ABRASION AND LACERATION AGAINST THE RIGID GLOVE

RACERS DON'T WEAR ANY TYPE OF IMPACT PROTECTION ON THE HAND, MEANING THE WRIST/ARM TAKES THE FULL FORCE OF IMPACT

INTERSECTION

COULD INJURY ISSUES FACED BY WHEELCHAIR ATHLETES IN REGARDS TO GLOVES BE SOLVED BY LOOKING AT THEM THROUGH THE LENS OF FOOTWEAR DESIGN?

VELOX RACING KIT

A RACING UNIFORM DESIGNED FOR THE ERGONOMIC, THERMOREGULATORY, AND PROTECTIVE NEEDS OF WOMEN'S WHEELCHAIR RACERS

SUMMER 2020
TOKYO PARALYMPIC GAMES
ELITE WOMEN WHEELCHAIR RACERS
FOB $50

BODY MAPPED VENTILATION

LASER CUT VENTILATION FOCUSED ON THE STOMACH AREA WHERE SWEAT COLLECTS THE MOST

ERGONOMIC SILHOUETTE

HIGHER RISE/LONGER SILHOUETTES IN BACK AND SHORTER/LOWER IN FRONT TO ACCOMODATE FORWARD LEAN. FITTED TO THE ANTHROPOMETRY OF WHEELCHAIR RACERS

MINIMAL DETAILS

LOW PROFILE EDGES & SEAMS TO MINIMIZE CHAFING RISK

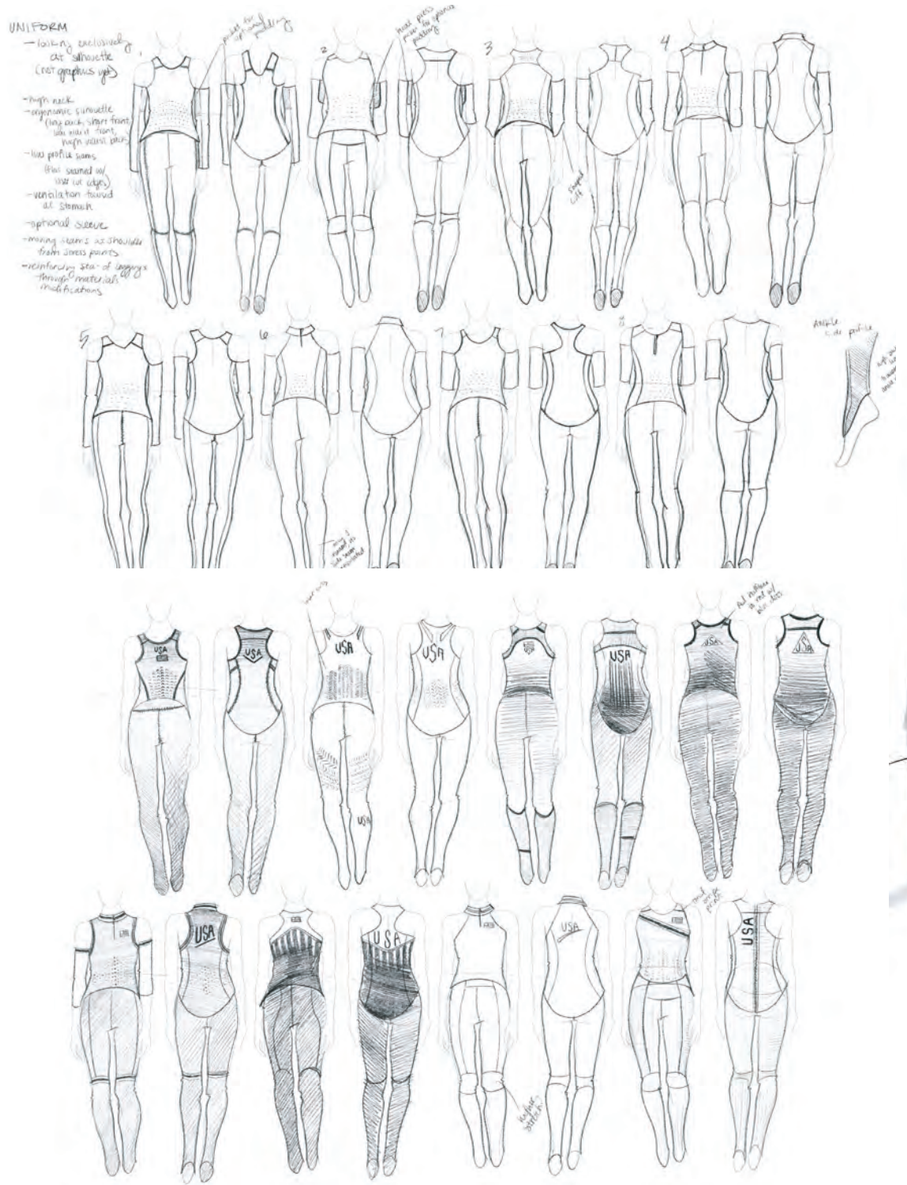
HIGH COVERAGE & PROTECTIVE SILHOUETTE

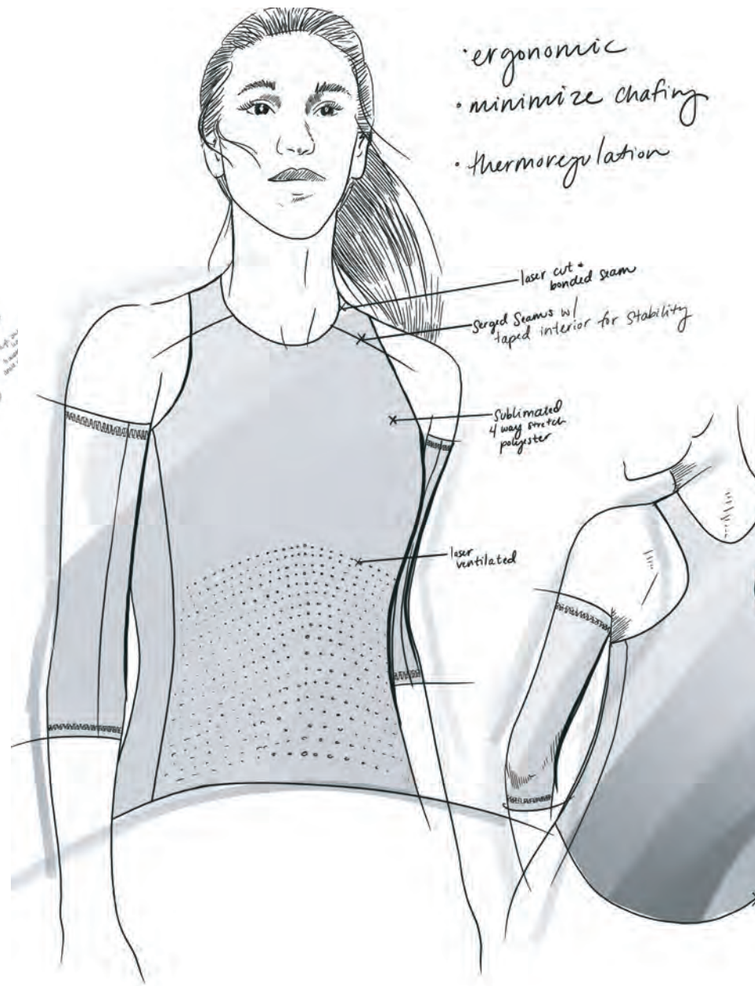
HIGH NECKLINE, LONG TIGHTS, AND SLEEVES TO PROTECT BODY FROM RACING CHAIR AND KEEP ATHLETE COMFORTABLE

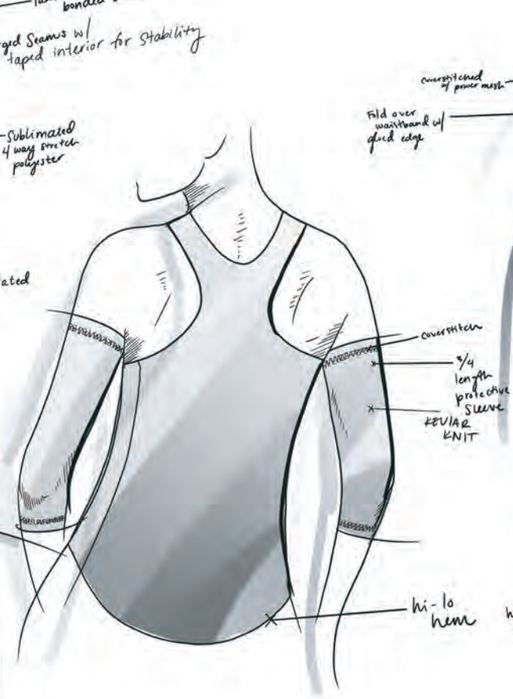
POSITIONING INFORMED GRAPHICS

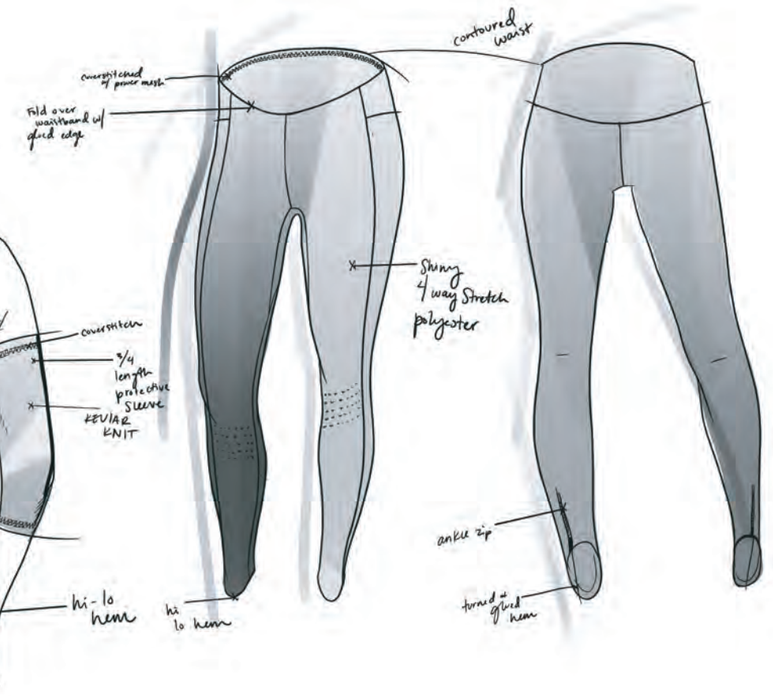
GRAPHICS VISIBLE BY CAMERA WHILE ATHLETE IS COMPETING, LOCATED ON SLEEVES, BACK, AND HIGH CHEST

VELOX RACING KIT

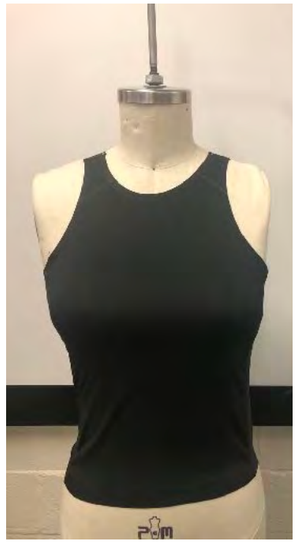


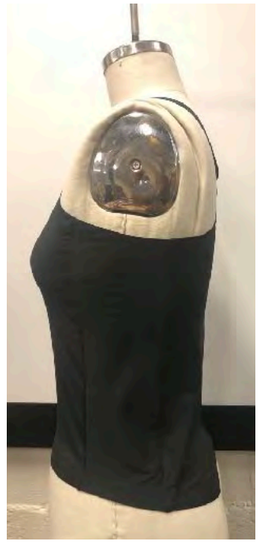


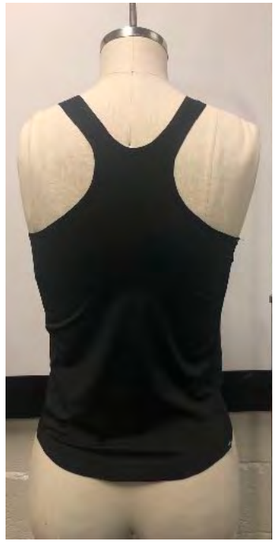




PROTOTYPES







TOP:

-SILHOUETTE

-EDGE FINISHES

LEGGINGS:

-WAISTBAND SHAPE

-MINIMIZING EDGES/DETAILS

-STREAMLINING SILHOUETTE

VELOX WEATHERPROOF APPAREL

ERGONOMIC & PERFORMANCE DRIVEN TRAINING APPAREL TO PROTECT RACERS FROM THE ELEMENTS

SUMMER 2020
TOKYO PARALYMPIC GAMES
ELITE WOMEN WHEELCHAIR RACERS
RETAIL PRICE $350
FOB $87

FITTED & ERGONOMIC SILHOUETTE

FITTED AROUND WAIST & HIP TO FIT INTO CHAIR SEAT, SHORTER FRONT & LONGER BACK

BODY MAPPED STRETCH

STRETCH PANELS TO ALLOW FOR TIGHTER FIT AROUND WAIST & HIP AND HIGHER MOBILLITY IN SHOULDER/BACK/CHEST REGION

BREATHABLE WEATHER PROTECTION

KEEP ATHLETE COMFORTABLE & DRY IN RAINY CONDITIONS

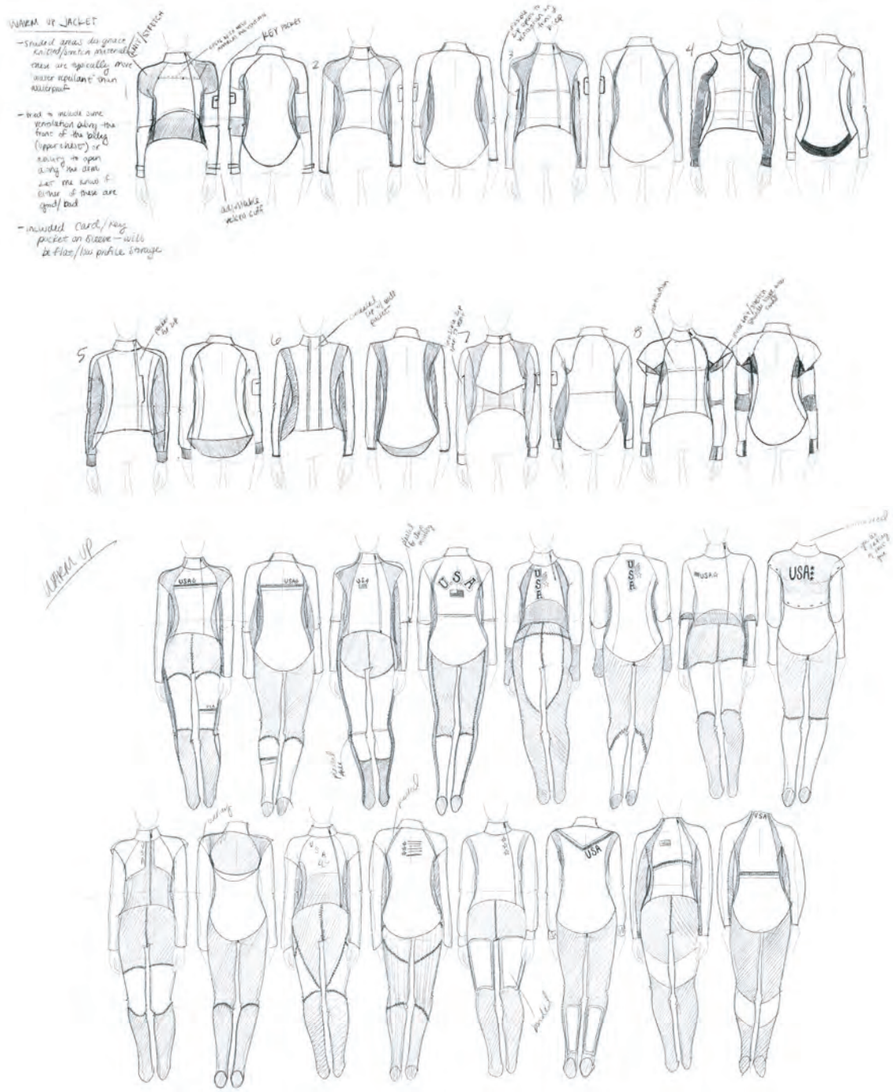
MINIMAL DESIGN

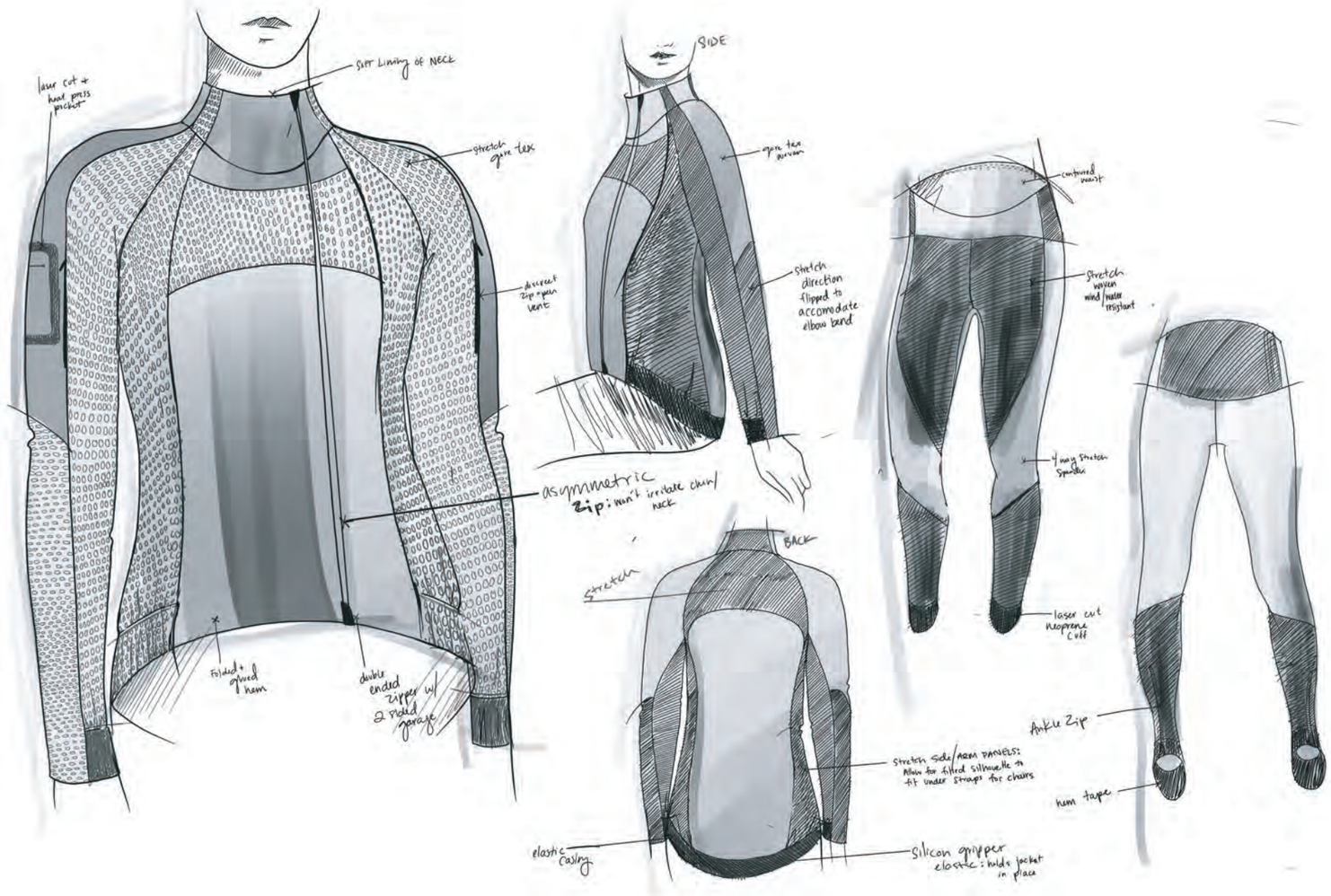
ELIMINATE DETAILS UNUSEABLE TO ATHLETE THAT WOULD CAUSE EXCESS BULK I.E. FRONT POCKETS, HOODS, ETC...

POSITIONING INFORMED GRAPHICS

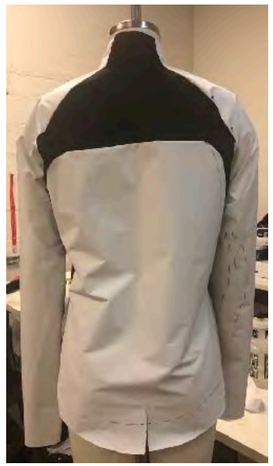
UTILIZE BACK & SLEEVE FOR GRAPHICS THAT ARE VISIBLE WHILE ATHLETE IS TRAINING

VELOX WEATHERPROOF APPAREL





PROTOTYPES

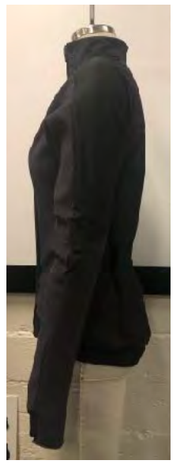
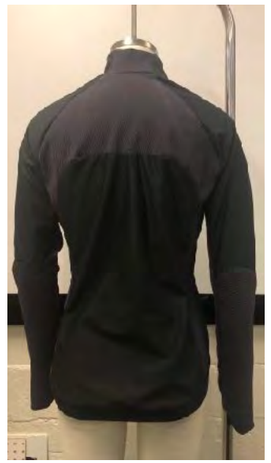

JACKET:

-SHOULDER/ARM MOBILITY

-COLLAR SHAPE

-HEM/CUFF

-STYLE LINE PLACEMENT


LEGGINGS:

-WAISTBAND SHAPE

-SHAPE/PLACEMENT OF WIND PANELING

-MATERIALS

GOLD MEDAL GLOVES

RACING GLOVES DESIGNED TO PROTECT THE HAND AND MINIMIZE WRIST STRAIN WITHOUT IMPACTING PERFORMANCE

SUMMER 2020
TOKYO PARALYMPIC GAMES
ELITE WHEELCHAIR RACERS
RETAIL PRICE $300
FOB $75

FOAM PROTECTED HITTING SURFACE

MINIMIMIZE IMPACT INJURY AND ALLOW FOR A MORE SECURE GRIP ON THE PUSH RIM

TREAD ENHANCED RUBBER

ENHANCE TRACTION ON PUSH RIM IN HUMID CONDITIONS & PROVIDE A PERFORMANCE AESTHETIC

SLEEK & FLUID GEOMETRY

PROVIDE A PERFORMANCE AESTHETIC THAT ELEVATES THE SERIOUSNESS & PERFORMANCE NEEDS OF THE SPORT

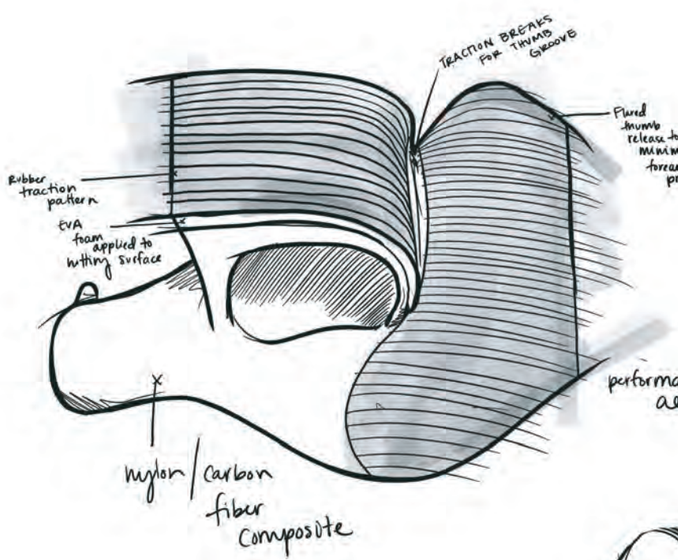
FLARED THUMB SHAPE

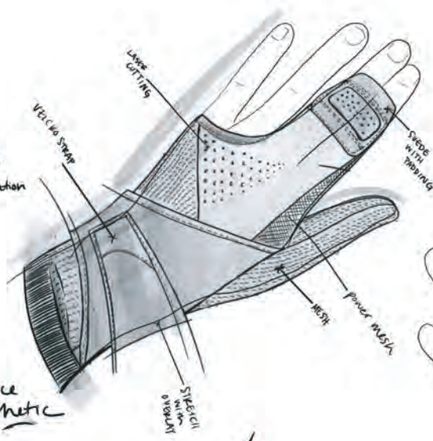
MINIMIZE EXCESSIVE FOREARM PRONATION TO ENCOURAGE A MORE NEUTRAL POSITION IF THE ARM & WRIST

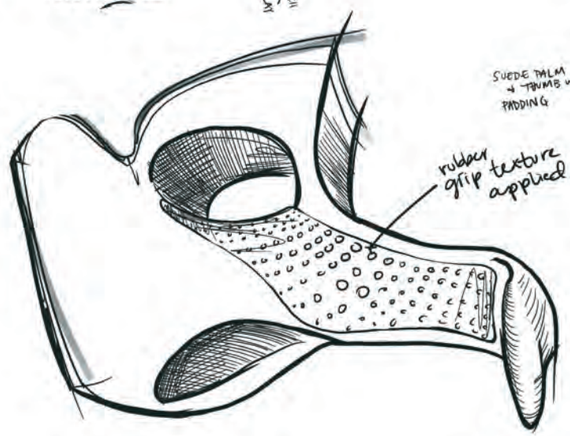
SUEDE FINGER PROTECTION

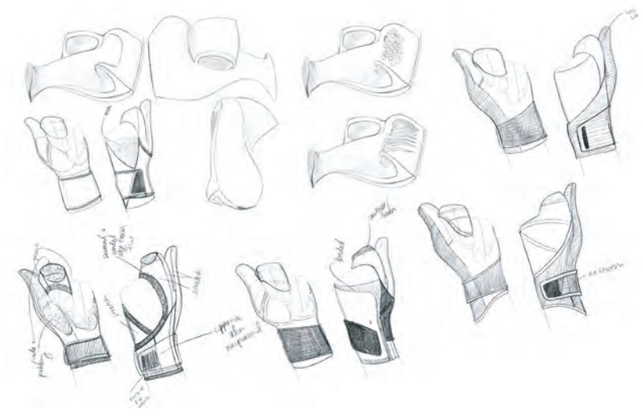
PROTECT MIDDLE AND POINTER FINGERS FROM ABRASIONS BY THE RIGID GLOVE

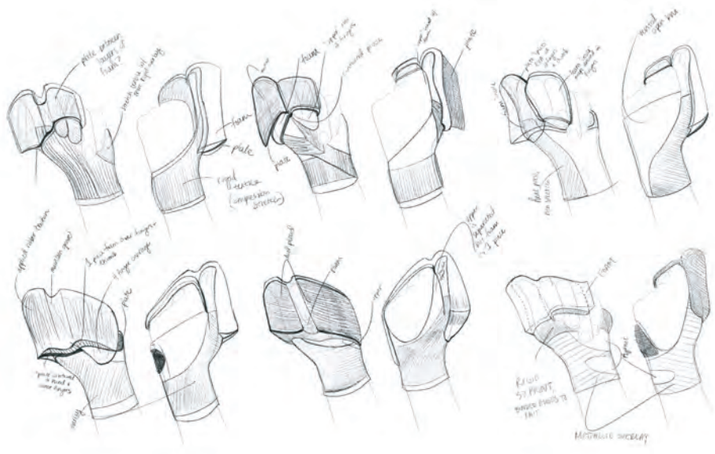
GOLD MEDAL GLOVES











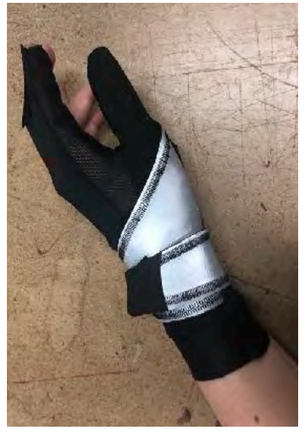
PROTOTYPES










SOFT GLOVE:

-FINGER ARTICULATION

-MATERIAL

-STRAP SHAPE/PLACEMENT

RIGID GLOVE:

-LEARNING FUSION 360

-STREAMLINING SILHOUETTE

-MAINTAINING FIT

-HAND COMFORT

VELOX

SARAH KLECKER
UNIVERSITY OF OREGON
SPORTS PRODUCT DESIGN

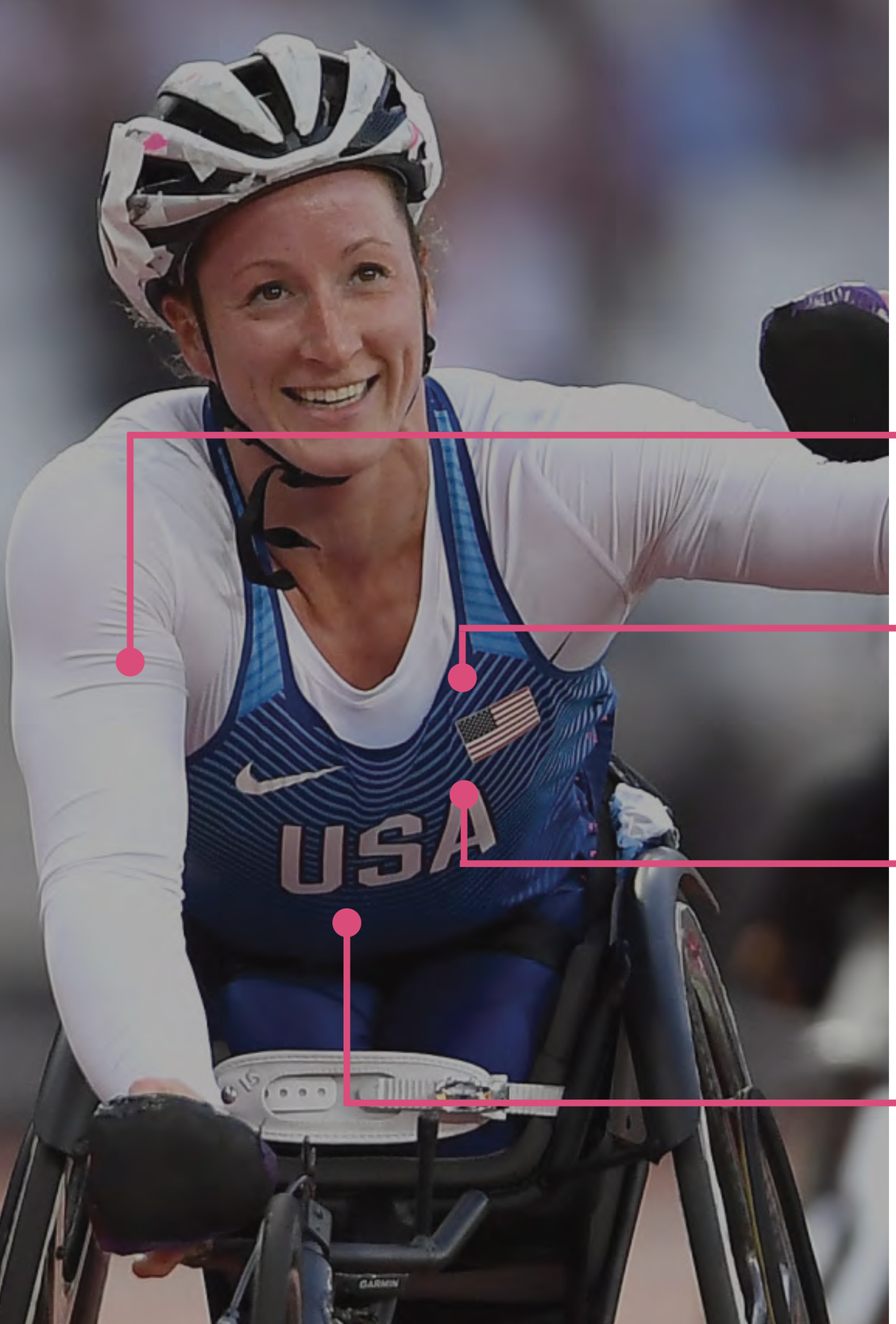
SARAH KLECKER *DESIGNER INTRO*

WHEELCHAIR RACING ATHLETES AT THE PARALYMPICS ARE WEARING UNIFORMS THAT AREN'T DESIGNED FOR THE INTRICACIES OF THEIR SPORT

INSTEAD THEY ARE ISSUED UNIFORMS & TRAINING APPAREL DESIGNED FOR STANDING TRACK ATHLETES THAT DON'T MEET THEIR NEEDS

"THE TIGHTS HAD THESE LITTLE RUBBERY THINGS ON THEM. THEY LOOKED COOL BUT WE COULDN'T GET INTO OUR CHAIRS WITH THEM"

-PARALYMPIC RACER YEN HOANG



PARALYMPIC UNIFORM *ATHLETE INSIGHT*

PARALYMPIC RACERS: YEN HOANG, ARIELLE RAUSIN, & SUSANNAH SCARONI

PROTECTION

"IT'S COMMON TO GET CHAFING NEAR YOUR ARMPITS. A LOT OF ATHLETES PERIODICALLY GET CUTS & BRUISES ON THEIR BICEPS."

FIT

"WHEN WE GET TEAM USA GEAR, IT'S JUST GENERIC...SIZING, BUT OBVIOUSLY OUR LOWER BODIES ARE A LOT SMALLER"

GRAPHICS

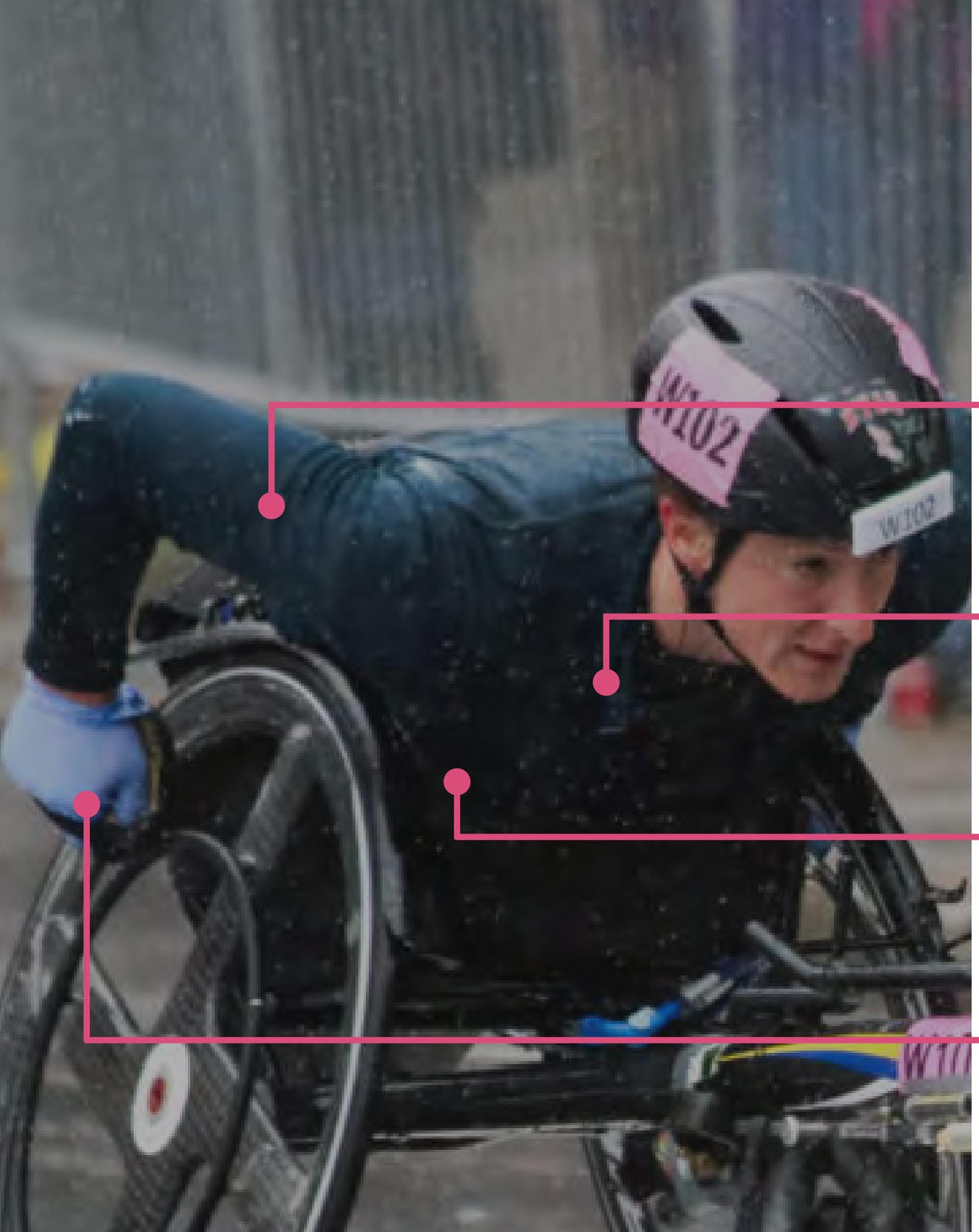
CENTER CHEST GRAPHICS AREN'T VISIBLE WHILE ATHLETE IS COMPETING

THERMOREGULATION

ALL ATHLETES SURVEYED MENTIONED STOMACH & TORSO SWEAT AS AN ISSUE

“NOT HAVING IDEAL WATERPROOF GEAR, WE DUCT TAPED TRASH BAGS BENEATH SOME THICKER LONG SLEEVES”

-SUSANNAH SCARONI ON THE 2018 BOSTON MARATHON



TRAINING APPAREL *ATHLETE INSIGHT*

PARALYMPIC RACERS: YEN HOANG, ARIELLE RAUSIN, AMANDA MCGREGORY, & SUSANNAH SCARONI

MOBILITY

TRADITIONAL RUNNING & CYCLING JACKETS LACK THE SHOULDER MOBILITY REQUIRED BY RACERS, ESPECIALLY WHEN APPAREL IS LAYERED

FIT

APPAREL THAT IS LARGE ENOUGH TO ALLOW MOBILITY DOESN'T FIT INTO THE SNUG SEAT OF THE RACING CHAIR & IS BULKY WHEN ATHLETES LEAN FORWARD

EXCESS BULK

EXTRA FABRIC, POCKETS, & HOODS ARE UNNECESSARY & CAUSE DISCOMFORT

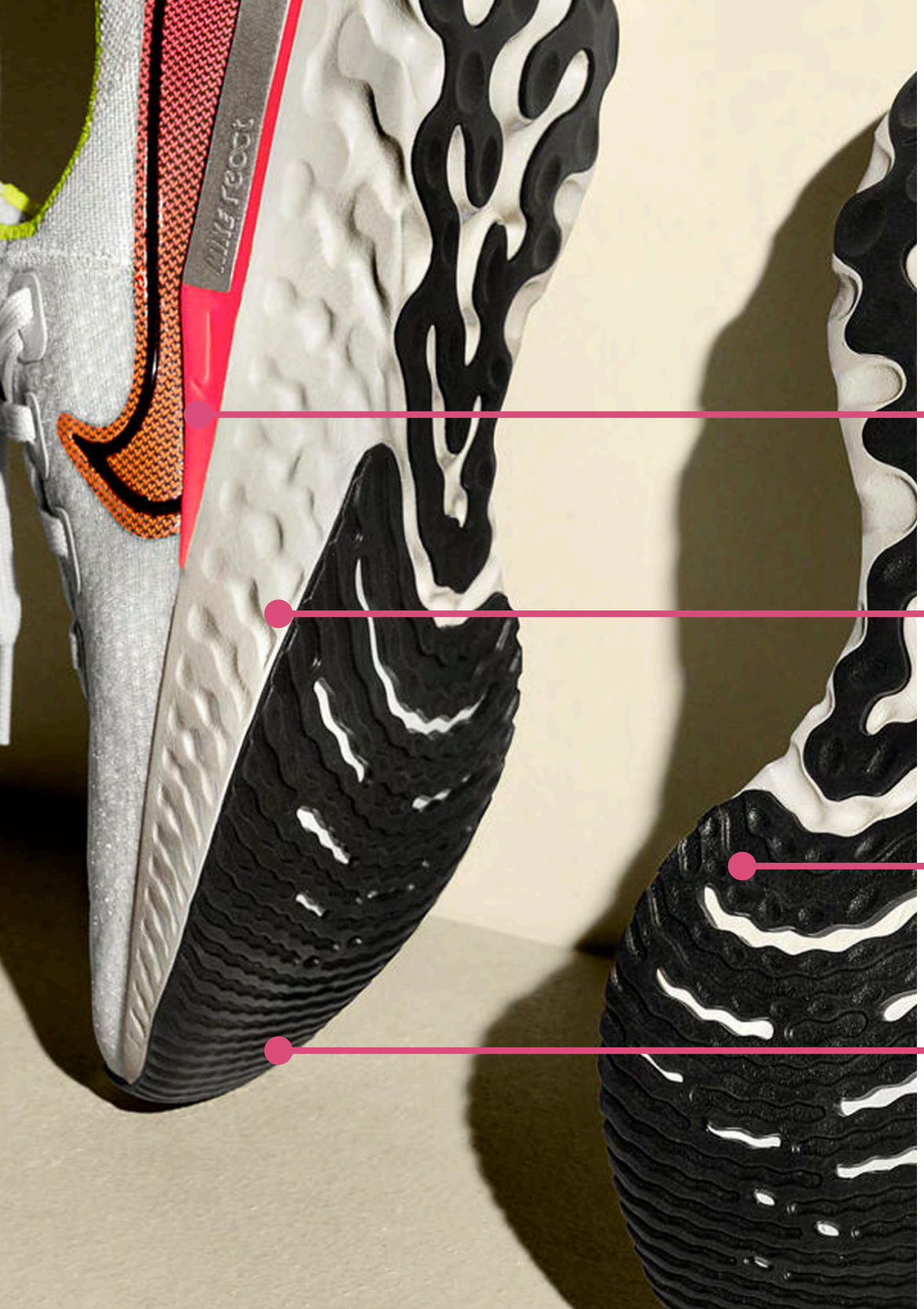
HAND PROTECTION

"I HAVE CUT PAIRS OF LIGHT GLOVES TO FIT INSIDE MY GLOVE WITH ONLY [RING & PINKY] FINGERS LEFT"

LATEX GLOVES ARE OFTEN WORN BENEATH PUSH GLOVES FOR PROTECTION

THE DYNAMIC WRIST MOVEMENTS OF WHEELCHAIR RACING BIOMECHANICS LEND THEMSELVES TO WRIST INJURIES & TENDONITIS OVER TIME

THE WRIST MOVES FROM A STATE OF RADIAL DEVIATION AT INITIAL CONTACT, THROUGH NEUTRAL POSITIONING, TO A HYPER PRONATED FOREARM WITH THE WRIST FLICKING INTO ULNAR DEVIATION AT THE END OF THE STOKE—ALL DONE WITH TREMENDOUS FORCE



HOW DO WE PROVIDE STABILITY & PREVENT OVERUSE INJURY IN FOOTWEAR?

AND CAN IT BE APPLIED TO RACING GLOVES?

RIGID PLATES & STABILIZERS

PROVIDES RESPONSIVENESS & PREVENTS EXCESS PRONATION

FOAM CUSHIONING

LESSENS IMPACT ON JOINTS

WIDE STABLE BASES & FLARED SHAPES

DISCOURAGES EXCESS PRONATION

TREADED RUBBER

PREVENTS SLIPPING

OPPORTUNITY:

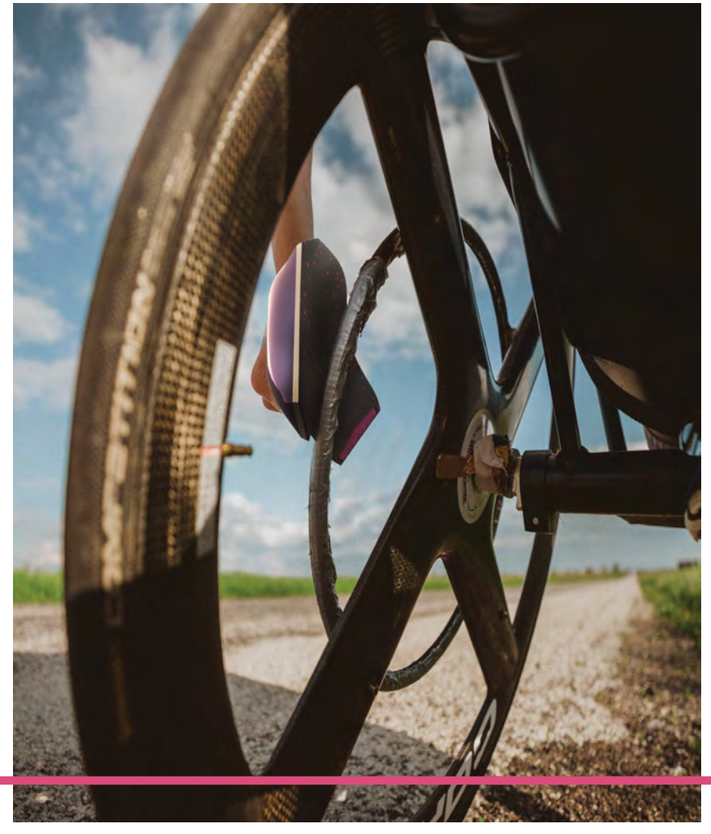
WEATHERPROOF TRAINING APPAREL & RACING UNIFORMS FOR THE TOKYO 2021 PARALYMPICS DESIGNED TO THE SPECIFICATIONS OF ELITE WOMEN'S WHEELCHAIR RACING ATHLETES THAT ALLOW THEM TO PERFORM AT THEIR BEST

PUSH GLOVES THAT ENHANCE PERFORMANCE AESTHETIC & MINIMIZE THE RISK OF WRIST OVERUSE INJURIES TO ALLOW ATHLETES TO TRAIN UNINTERRUPTED

VELOX

ERGONOMIC. ADAPTIVE. PERFORMANCE

VELOX *COLLECTION*



RACING KIT

_SINGLET

_COMPETITION LEGGINGS

_ARM SLEEVES

WEATHERPROOF APPAREL

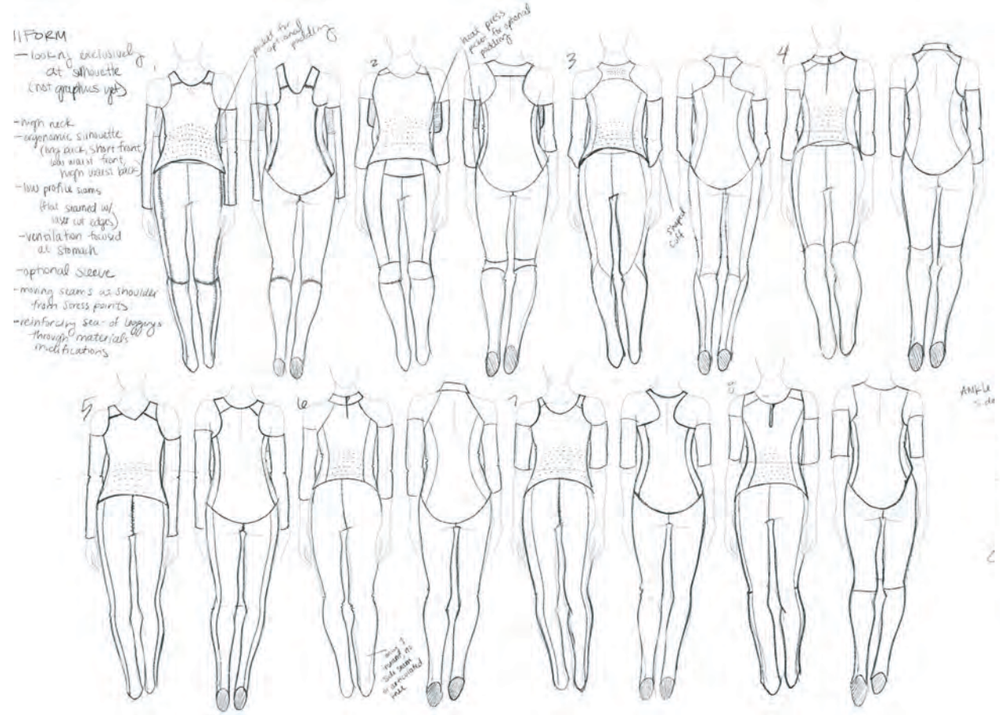
_RAIN JACKET

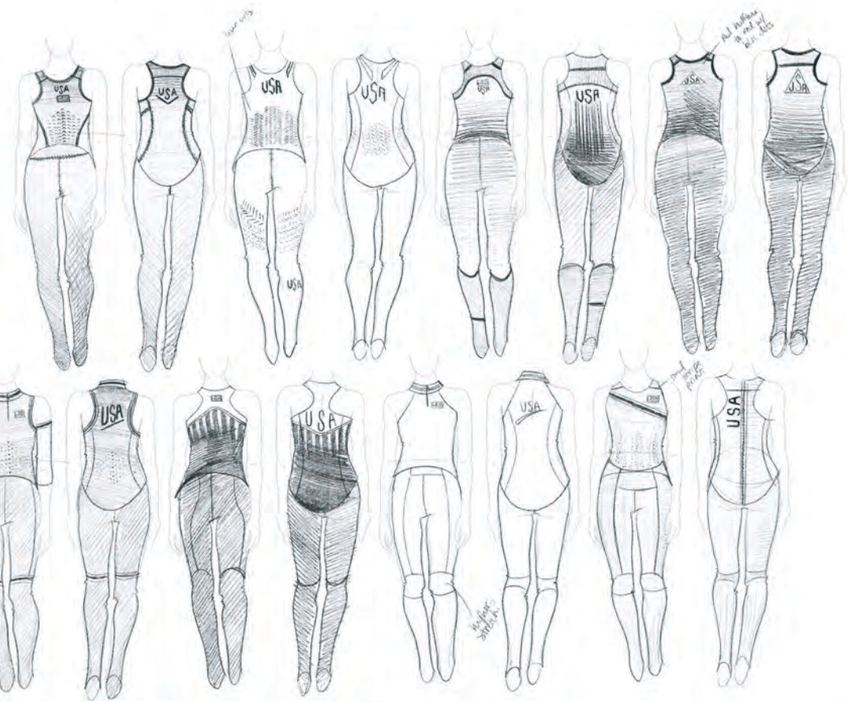
_TRAINING LEGGINGS

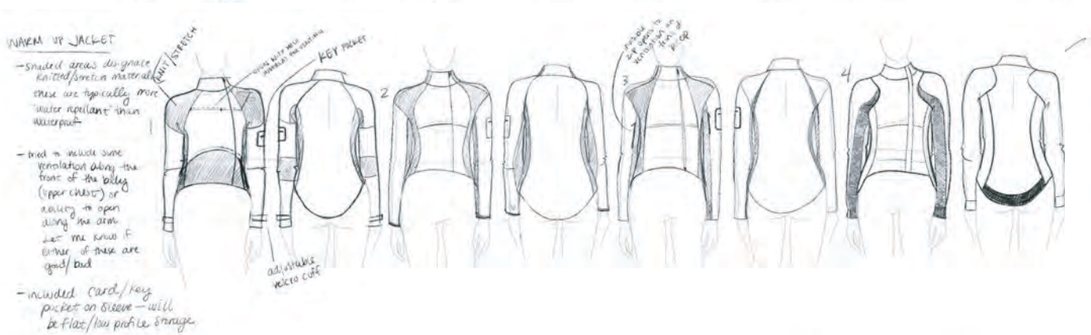
_THERMAL LOBSTER MITTS

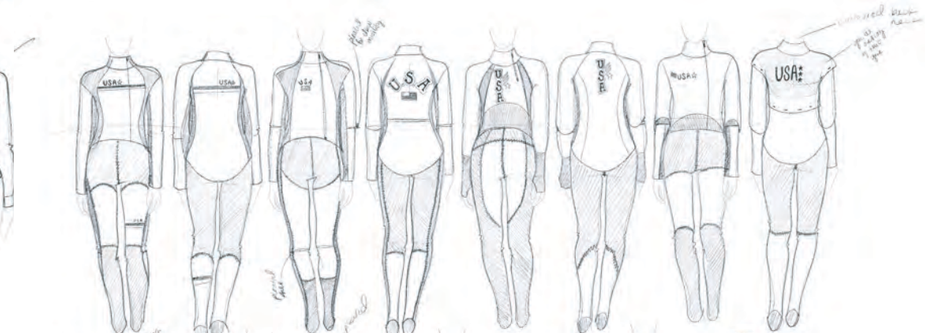
PUSH GLOVE

APPAREL *IDEATION*

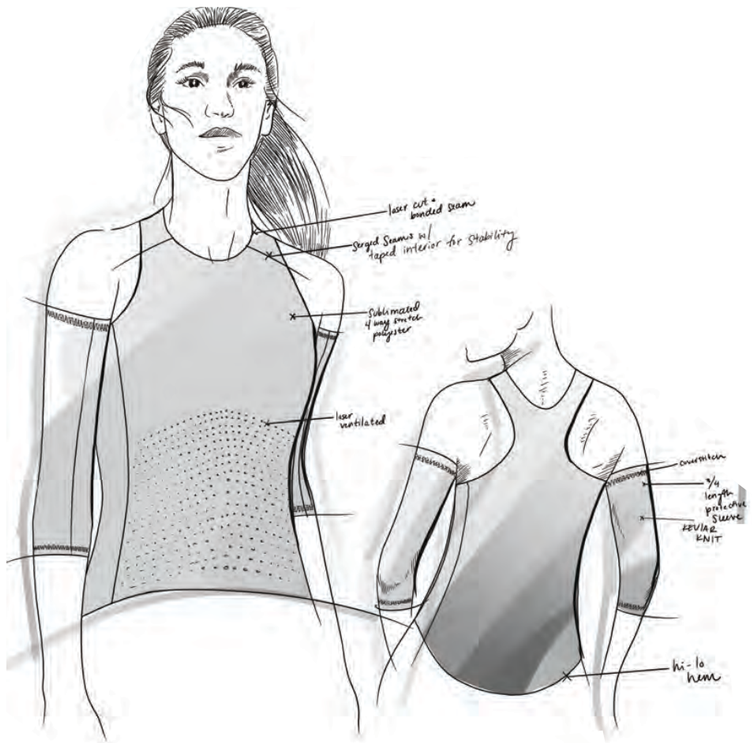


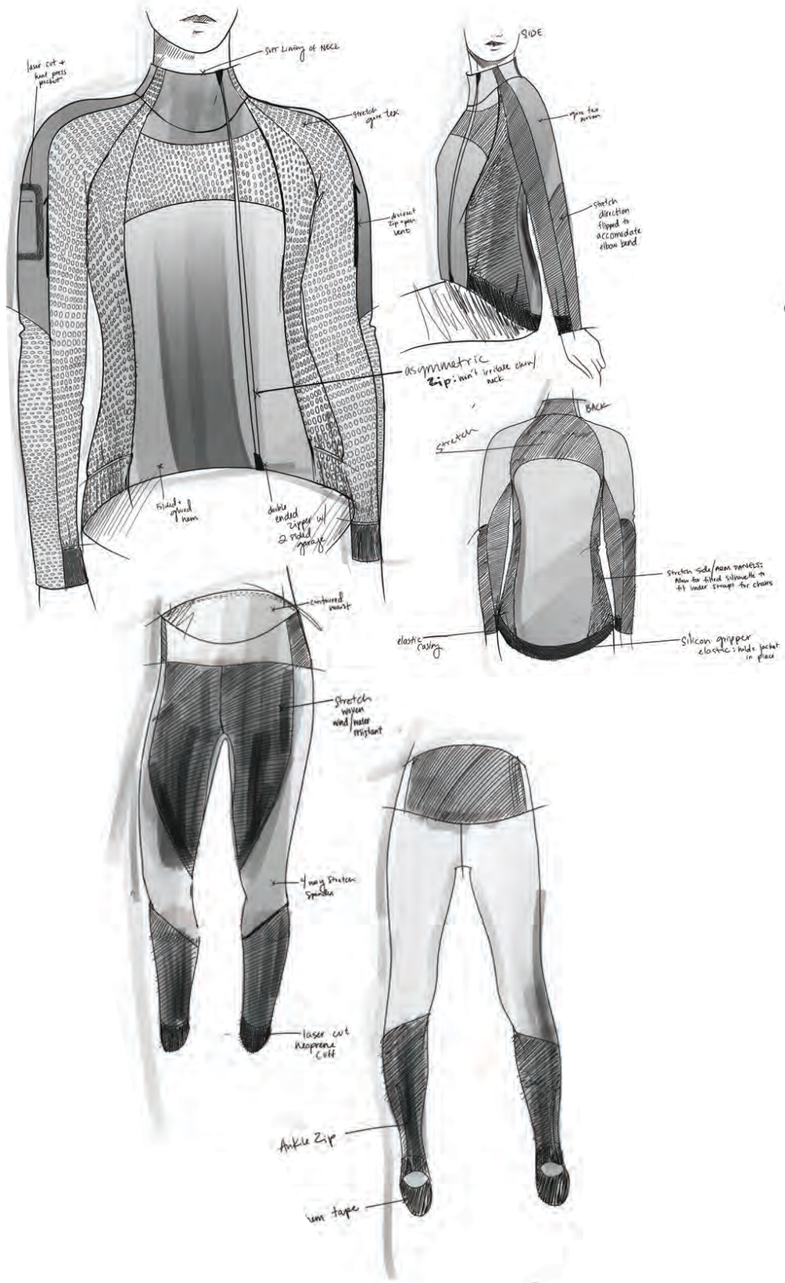


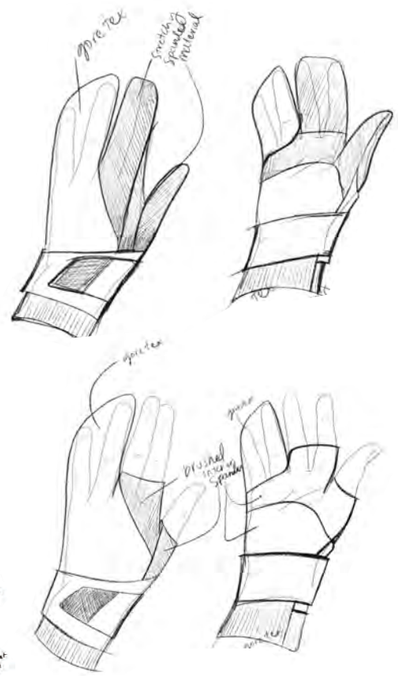




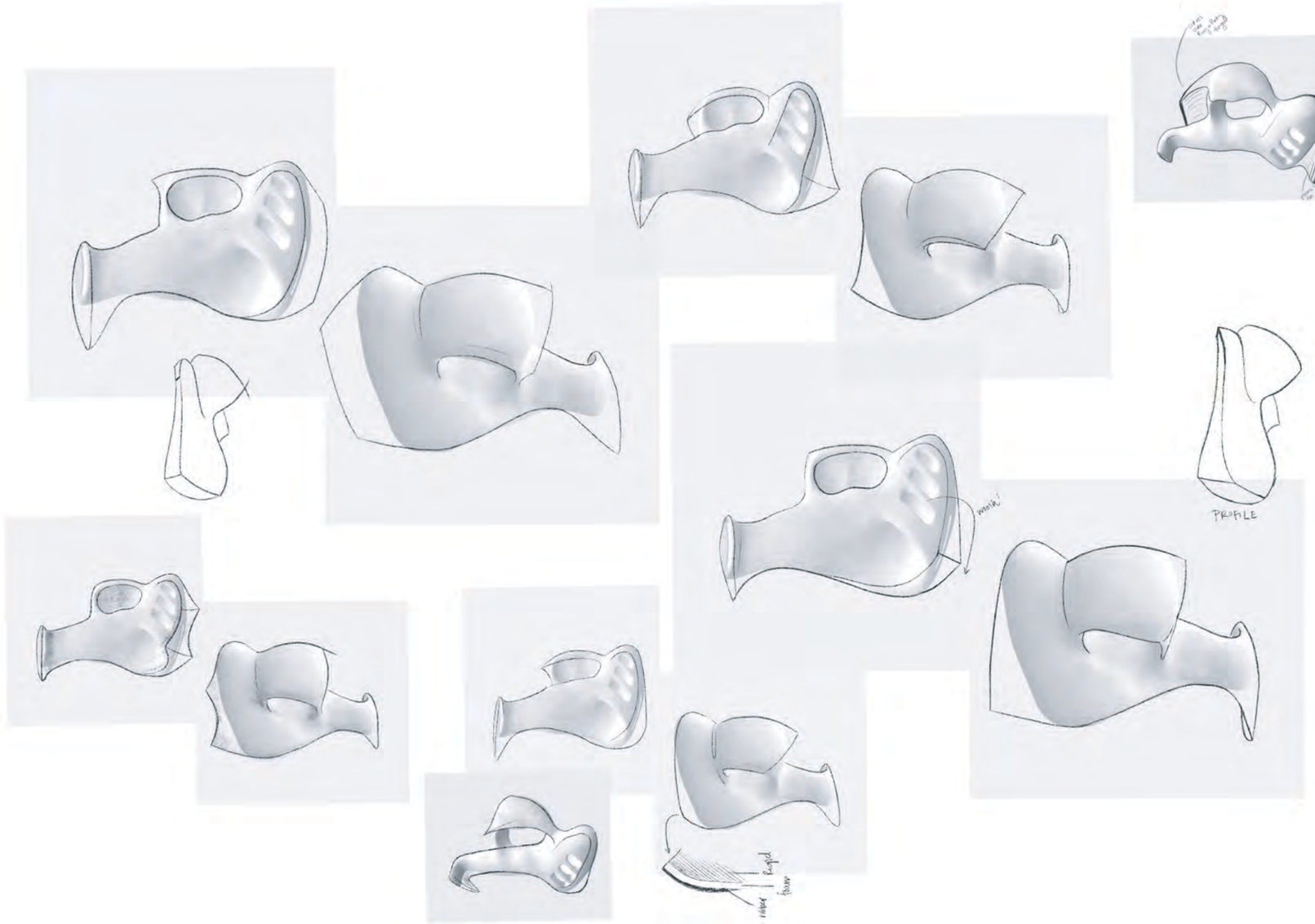
APPAREL *REFINEMENT*

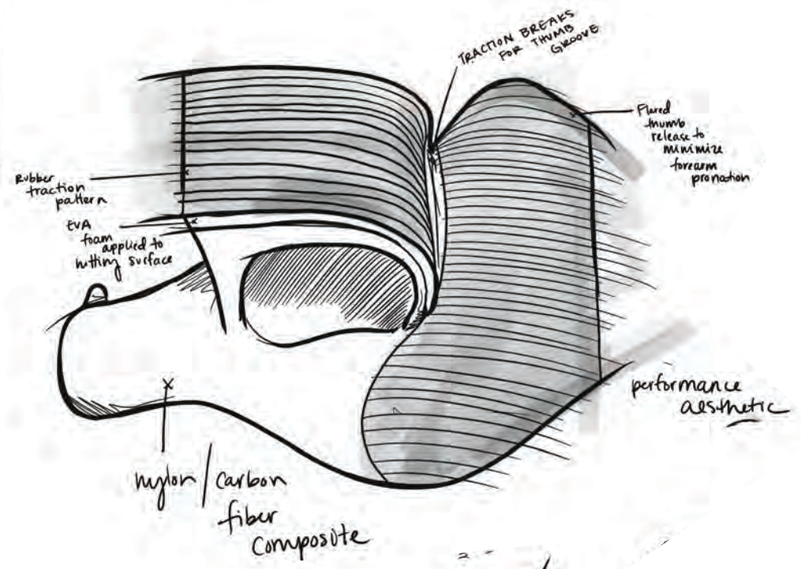


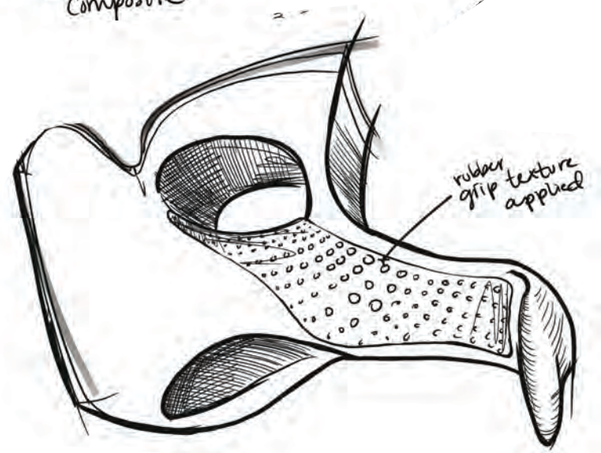




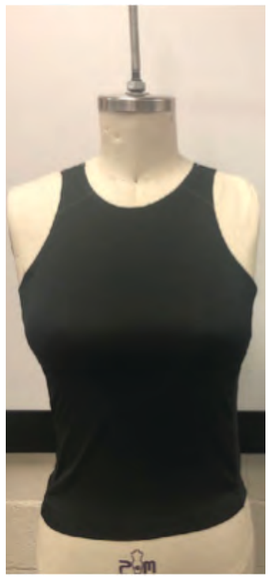
PUSH GLOVE *IDEATION & REFINEMENT*

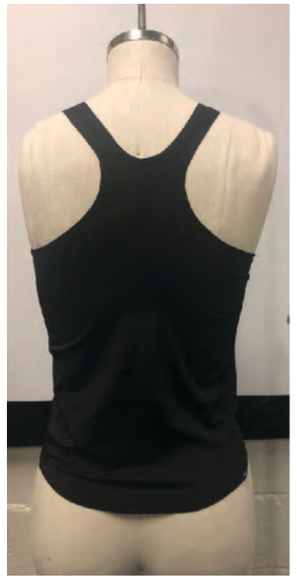






PROTOTYPING





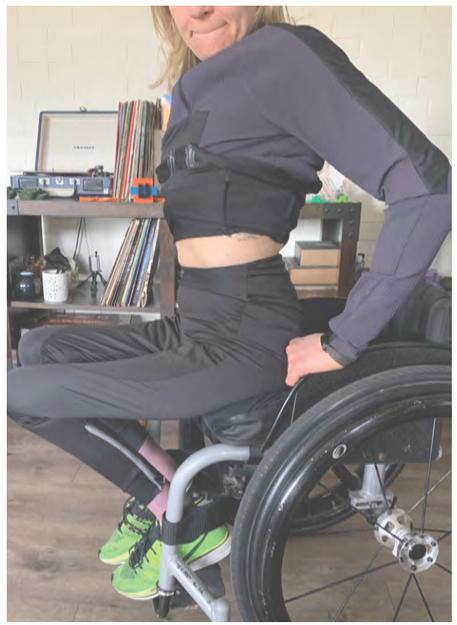
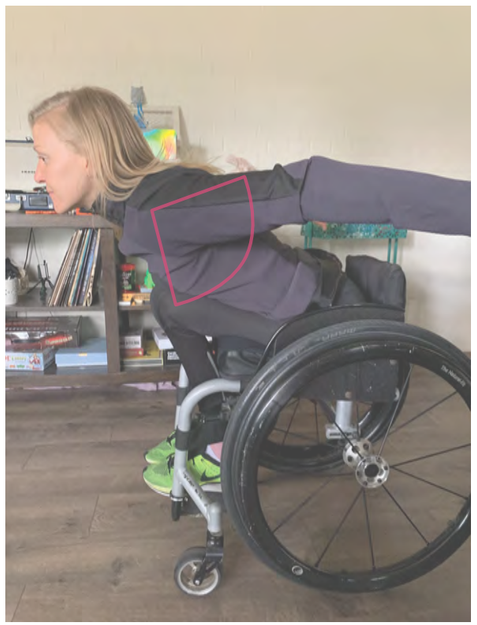
VALIDATION *FITTING*




UNIFORM

"I REALLY LIKE THE HIGH NECK, AND THE FABRIC IS NICE AND LIGHT."

"THE LEGGINGS COME UP TO A GOOD POINT, AND THE SLICK FABRIC IS GREAT, IT'LL MAKE IT EASY TO GET IN AND OUT OF THE CHAIR."


TRAINING APPAREL

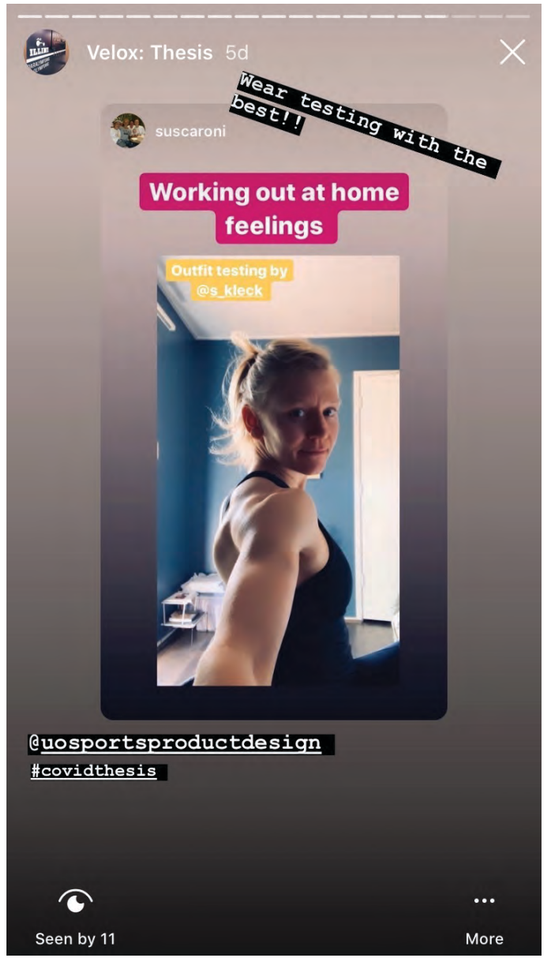
"I LIKE THE HIGH COLLAR AND THE FULL ZIP SO I CAN TAKE IT OFF WITHOUT REMOVING MY HELMET. IT SEEMS LIGHTWEIGHT AND LIKE IT WOULD ENABLE MOBILITY"

VALIDATION *PERCEPTION*

LOBSTER MITT

"I THINK A THIN SPANDEX-Y FABRIC ON THE GLOVE GRIPPING FINGERS WOULD BE GREAT! IT SEEMS THIN ENOUGH TO FIT INSIDE THE GLOVE AND MORE COMFORTABLE THAN FULL EXPOSURE"

VALIDATION *WEAR TEST*



UNIFORM

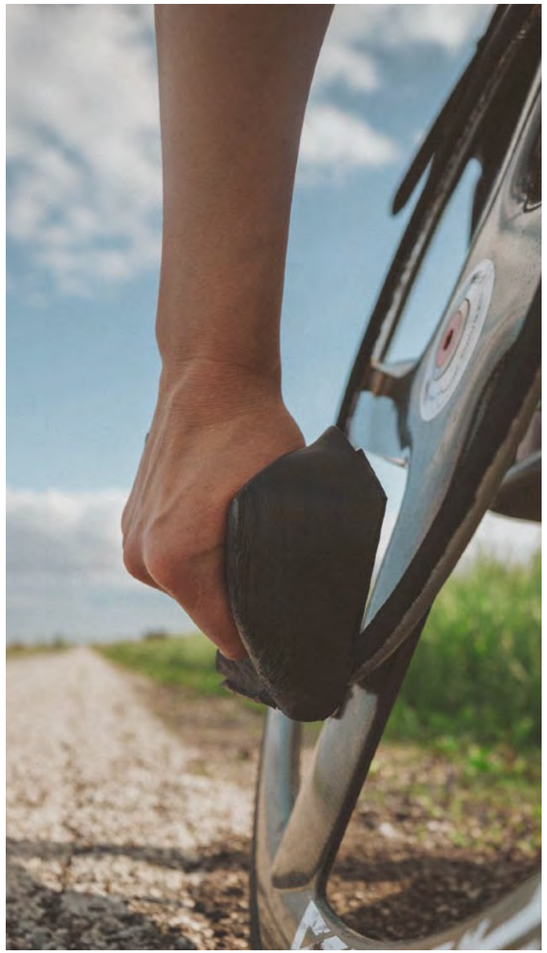
INDOOR WORKOUT ON ROLLER

"THEY'RE REALLY AWESOME, AND DIFFERENT FROM MY CURRENT OPTIONS"

TRAINING APPAREL

60 MIN WORKOUT, 44º F LIGHT RAIN

"THE JACKET PROVIDED NICE COVERAGE & WASN'T BULKY. IT PROVIDED FULL MOBILITY FOR THE ENTIRE WORKOUT"

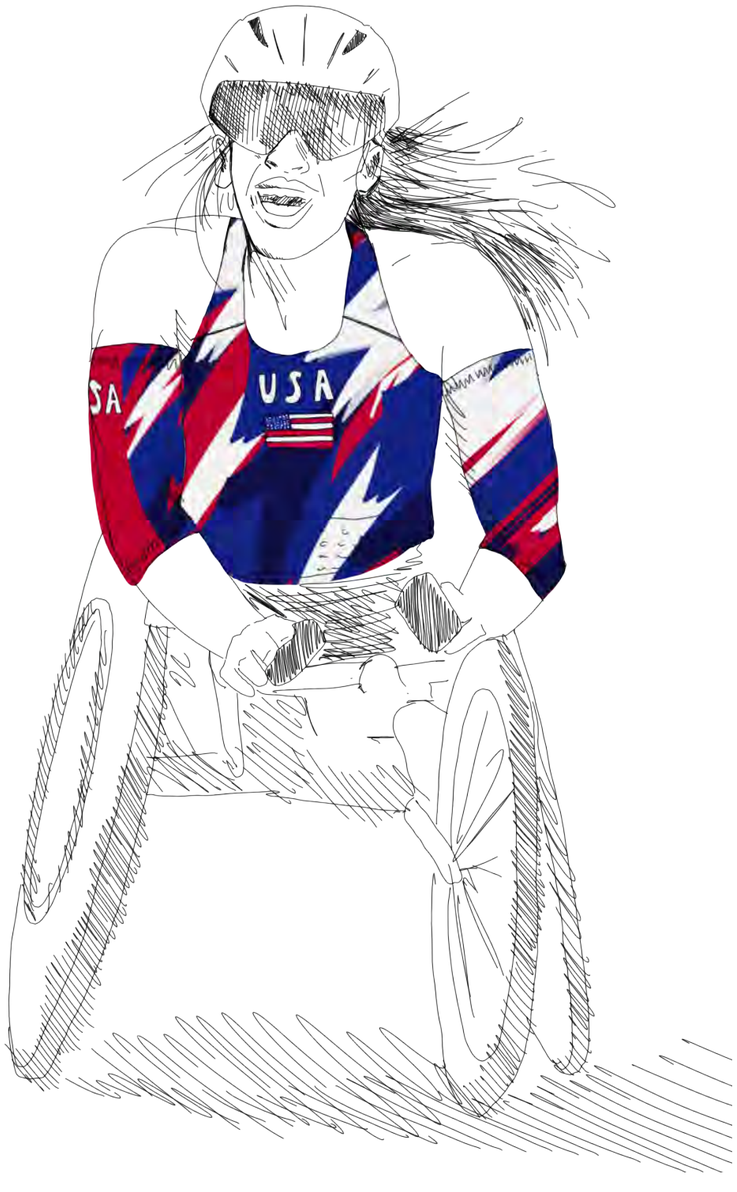


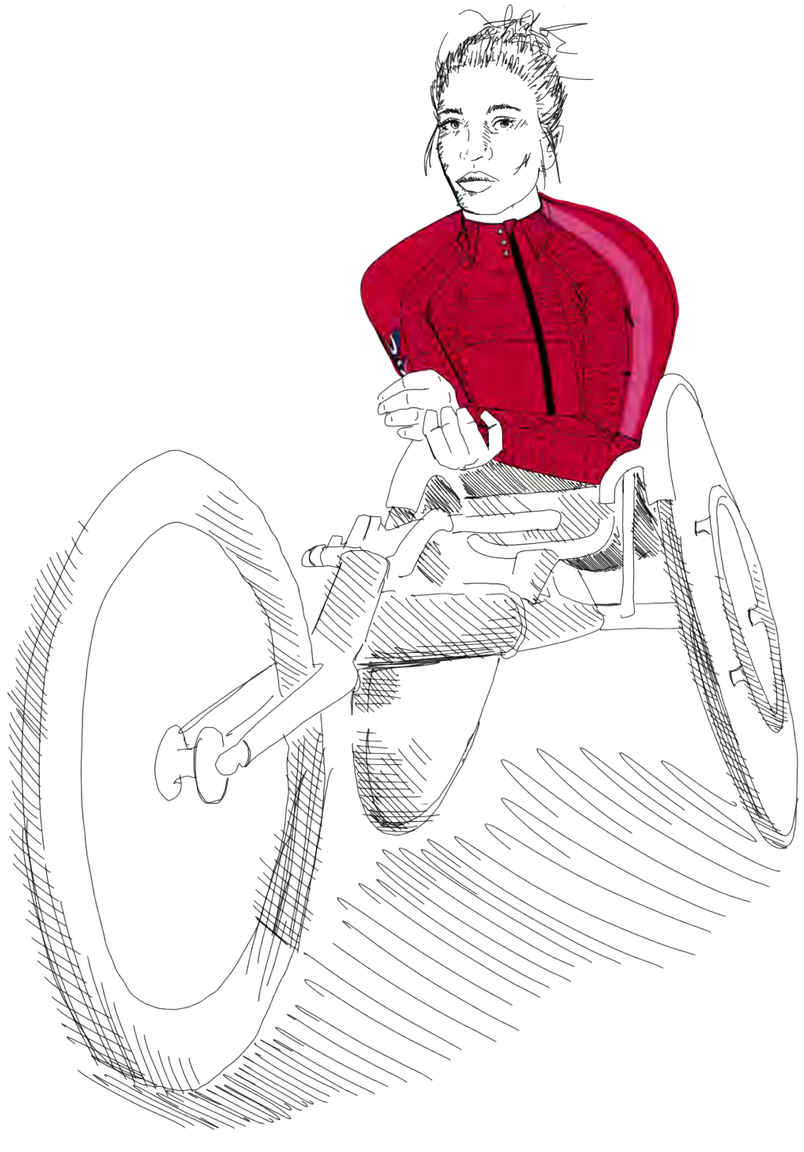
PUSH GLOVE

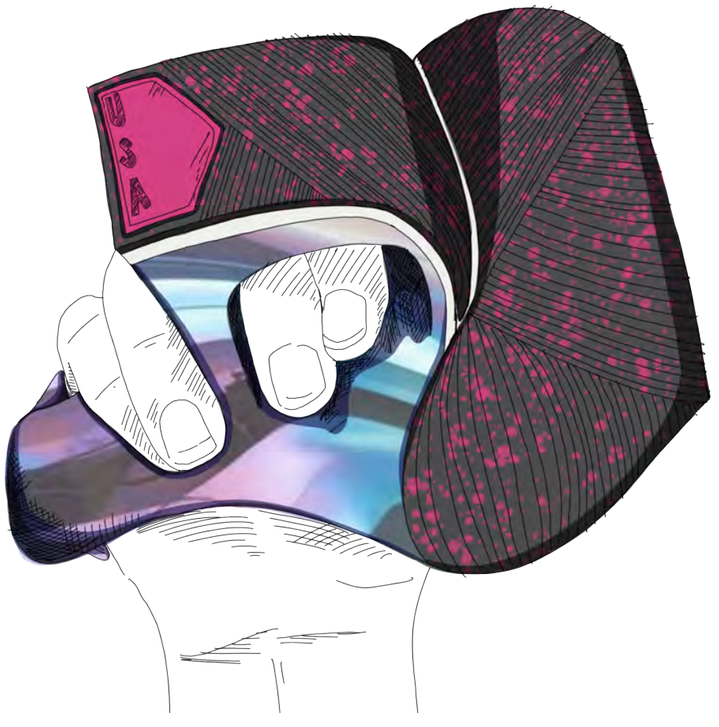
PUSH TEST DOWN STREET

"I COULD TELL IT WAS...MINIMIZING FOREARM PRONATION. I THINK IT MIGHT BE BENEFICIAL FOR CLIMBING WITH THE BIGGER SURFACE"

VELOX *COLOR & GRAPHIC TREATMENT*







VELOX *TEAM USA RACING KIT FOR*

BODY MAPPED VENTILATION

VENTILATION FOCUSED ON FRONT OF BODY WHERE RACERS SWEAT MOST

ERGONOMIC SILHOUETTE

CONTOURED TO THE ATHLETE POSITIONING. FITTED TO THE ANTHROPOMETRY OF WHEELCHAIR RACERS

POSITIONING INFORMED GRAPHICS

NATIONAL IDENTIFIERS VISIBLE WHILE ATHLETE IS IN WORKING POSITION

LOW PROFILE EDGES

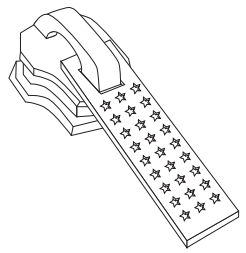
LASER CUT & BONDED HEMS & EDGES MINIMIZE CHAFING RISK

HIGH COVERAGE

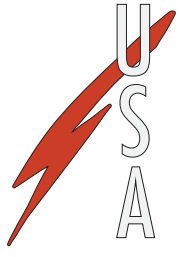
KEEPS RACERS COMFORTABLE & PROTECTED FROM CHAFING AGAINST THE CHAIR

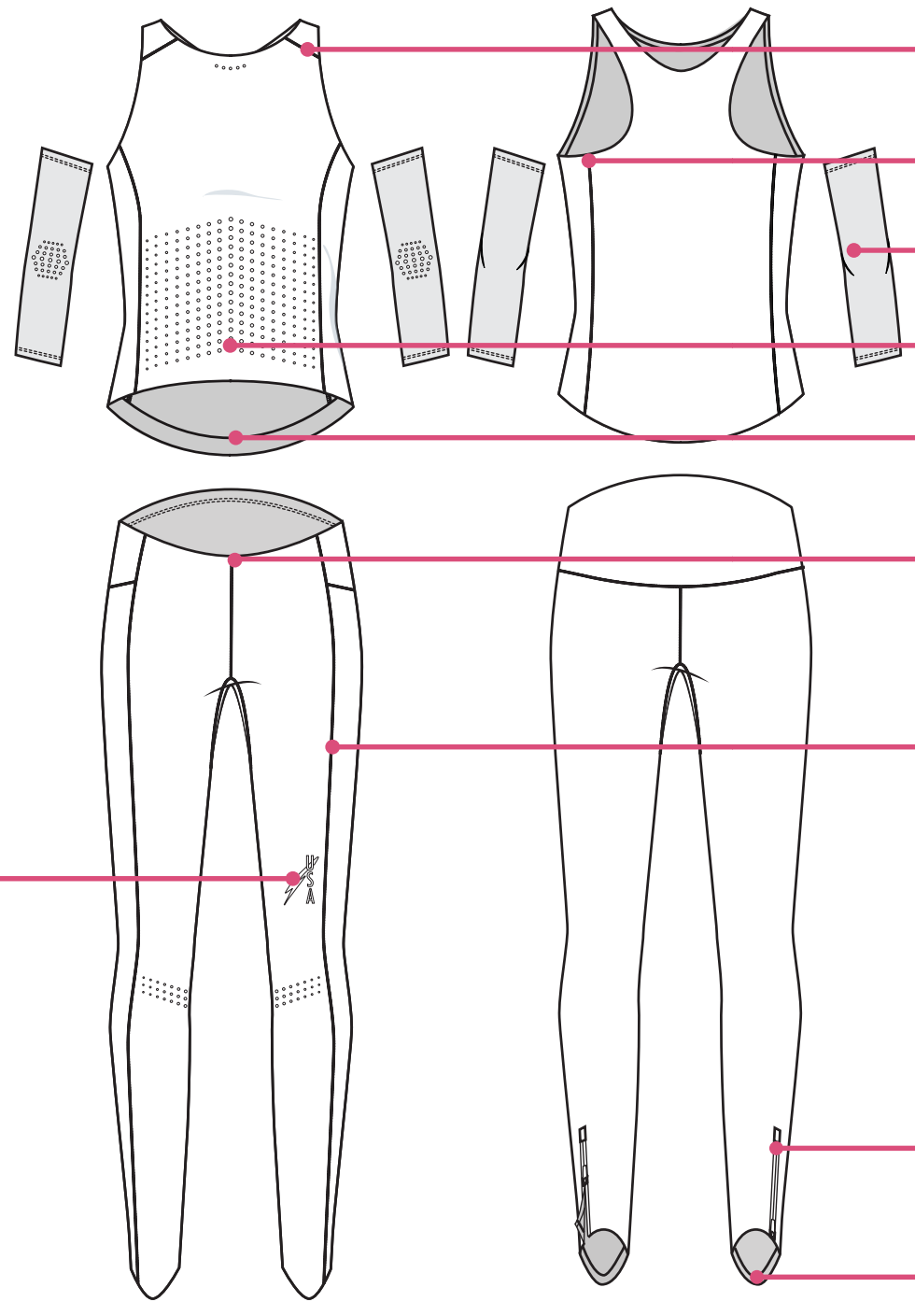
VELOX *TEAM USA RACING KIT FOR TOKYO 2021*

ANKLE ZIPPERS



LEG GRAPHIC





REINFORCED SHOULDER SEAM
_ PREVENTS TEARS AT SHOULDER STRESS POINT

PANELED DESIGN
_ LESSENS LIKLIHOOD OF UNDERARM CHAFING

3/4 ARM SLEEVE
_ PROTECTS RACER'S ARMS FROM ABRASION

BODY MAPPED VENTILATION
_ SEAMLESS SWEAT MANAGEMENT CONCENTRATED IN SWEAT ZONES

CONTOURED HEM
_ ACCOMODATES FORWARD LEAN & PREVENTS FABRIC FROM BUNCHING UP IN FRONT

FOLDOVER CONTOURED WAISTBAND
_ FOLDED & BONDED CONSTRUCTION
_ MINIMIZES BULK, PREVENTS CHAFING & IRRITATION

SHIFTED SIDE SEAM
_ MOVES SEAM AWAY FROM PRESSURE & CHAFING OF CHAIR

ANKLE ZIPPER
_ EASIER DONNING & DOFFING FOR PARAPLEGIC ATHLETES

CONTOURED ANKLE
_ BETTER ACCOMOCATE FLEXED POSITION OF FOOT

SINGLET

MATERIALS:

POLYESTER/SPANDEX KNIT
_ 4 WAY STRETCH
_ ALLOWS FOR OPTIMAL MOBILITY

CONSTRUCTION:
_ CUT & SEWN WITH FLATLOCK STITCHING
_ LASER CUT & BONDED EDGES
_ SUBLIMATED GRAPHICS

LEGGINGS

MATERIALS:

SLICK POLYESTER/SPANDEX KNIT
_ 4-WAY STRETCH
_ STRETCHY & TIGHT FITTING

CONSTRUCTION:
_ CUT & SEWN WITH FLATLOCK STITCHING
_ LASER CUT & BONDED EDGES
_ HEAT PRESS GRAPHICS

ARM SLEEVES

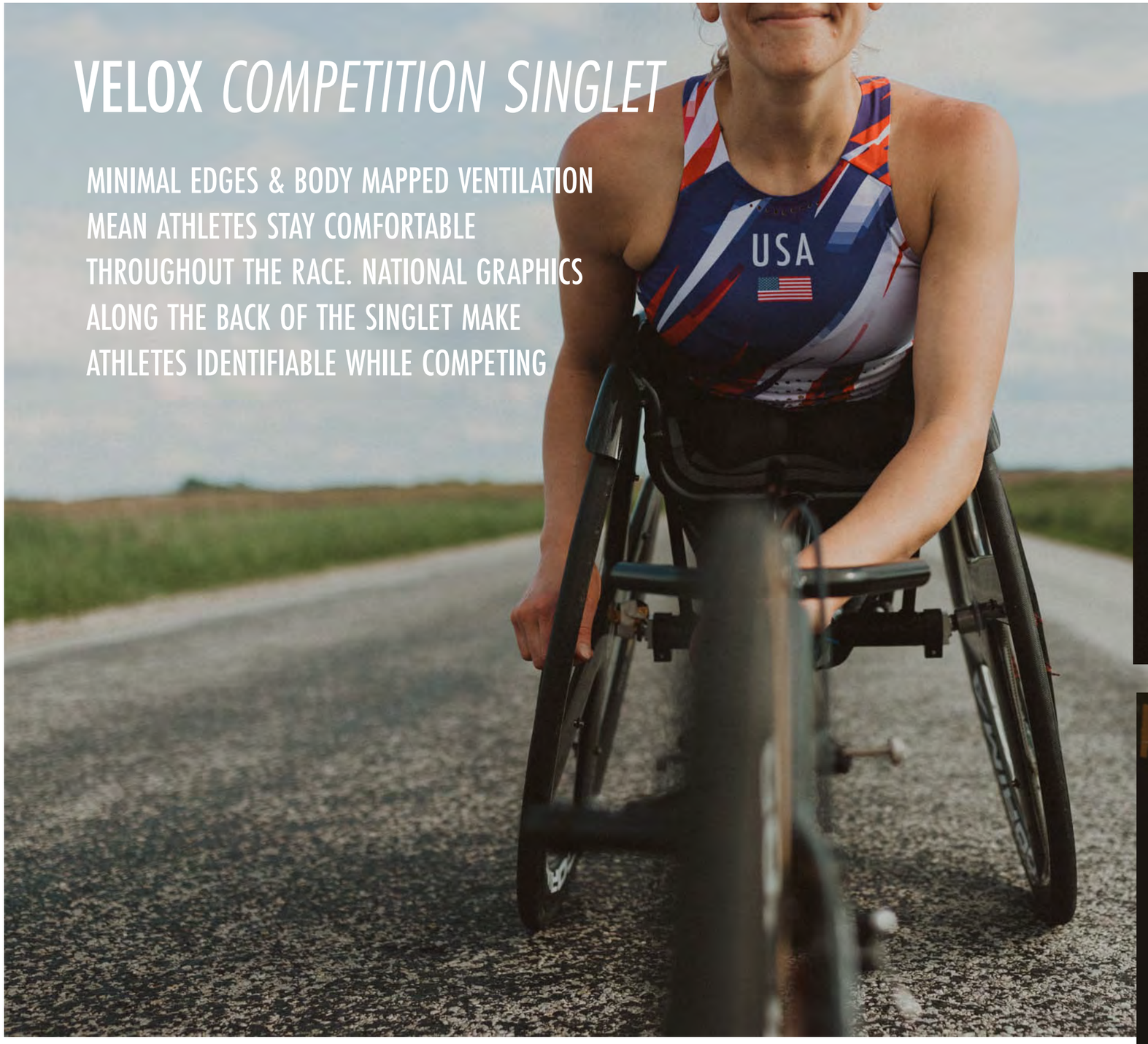
MATERIALS:

POLYESTER/SPANDEX/KEVLAR KNIT
_ 4-WAY STRETCH
_ PREVENTS INNER ARM ABRASION FROM CHAIR

CONSTRUCTION:
_ CUT & SEWN WITH FLATLOCK STITCHING
_ TURNED & COVERSTITCHED EDGES
_ SUBLIMATED GRAPHICS

VELOX *COMPETITION SINGLET*

MINIMAL EDGES & BODY MAPPED VENTILATION MEAN ATHLETES STAY COMFORTABLE THROUGHOUT THE RACE. NATIONAL GRAPHICS ALONG THE BACK OF THE SINGLET MAKE ATHLETES IDENTIFIABLE WHILE COMPETING

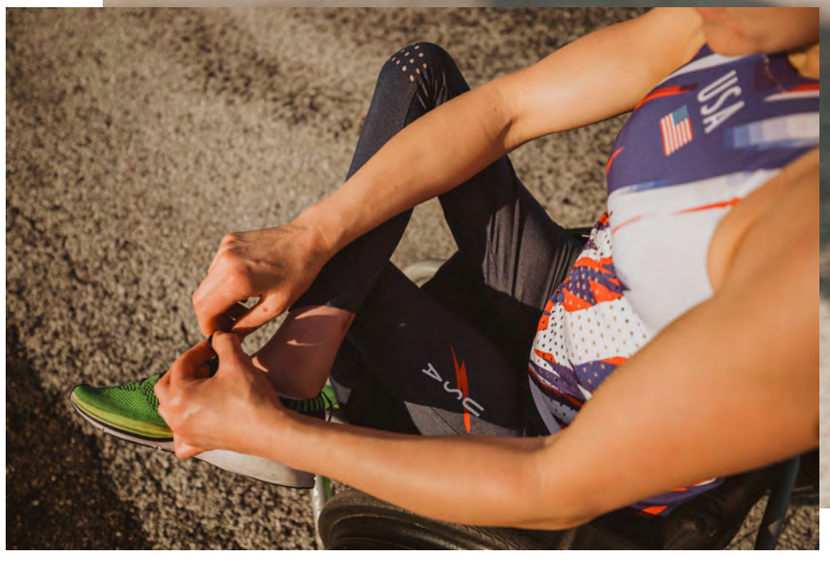


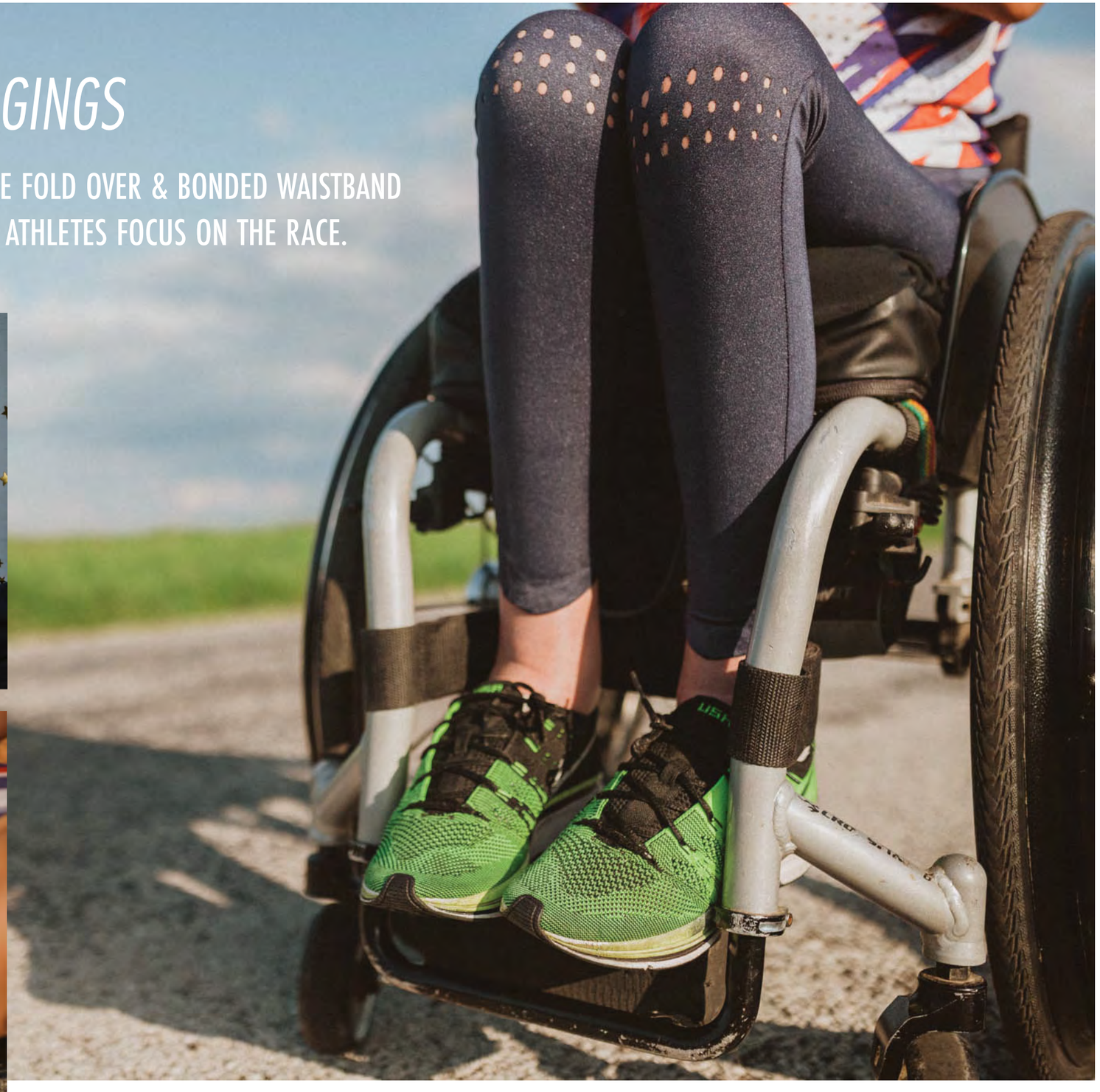
VELOX *ARM SLEEVES*

THE VELOX RACING SLEEVE PROVIDES PROTECTION THROUGH AN INNOVATIVE KEVLAR STRETCH KNIT WHILE VENTILATION & A 3/4 LENGTH MEAN ATHLETES STAY COOL

VELOX *COMPETITION LEGGINGS*

A CONTOURED SILHOUETTE & A LOW PROFILE FOLD OVER & BONDED WAISTBAND MAKES CLOTHING ISSUES DISAPPEAR TO LET ATHLETES FOCUS ON THE RACE.





VELOX *TEAM USA WEATHERPROOF TRAINING APPAREL*

BODY MAPPED STRETCH PANELS

PANELING AROUND CHEST, SHOULDERS, & SIDE OF BODY TO ALLOW TIGHT FIT & FULL MOBILITY

ERGONOMIC SILHOUETTE

CONTOURED TO THE ATHLETE POSITIONING. FITTED SNUGLY TO INTERACT WITH RACING CHAIR

GORE TEX ™ FABRICS

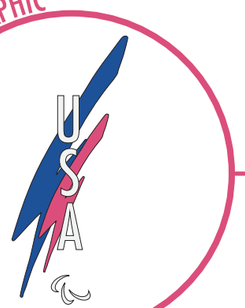
BREATHABLE WEATHER PROTECTION TO KEEP ATHLETE DRY & COMFORTABLE

MINIMAL DESIGN

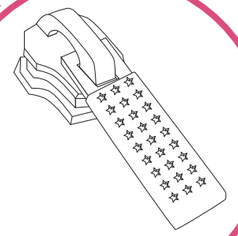
CONSIDERED STORAGE THAT REMAINS OUT OF THE ATHLETE'S WAY

VELOX *TEAM USA WEATHERPROOF TRAINING APPAREL*

ARM GRAPHIC



JACKET & ANKLE ZIPPERS



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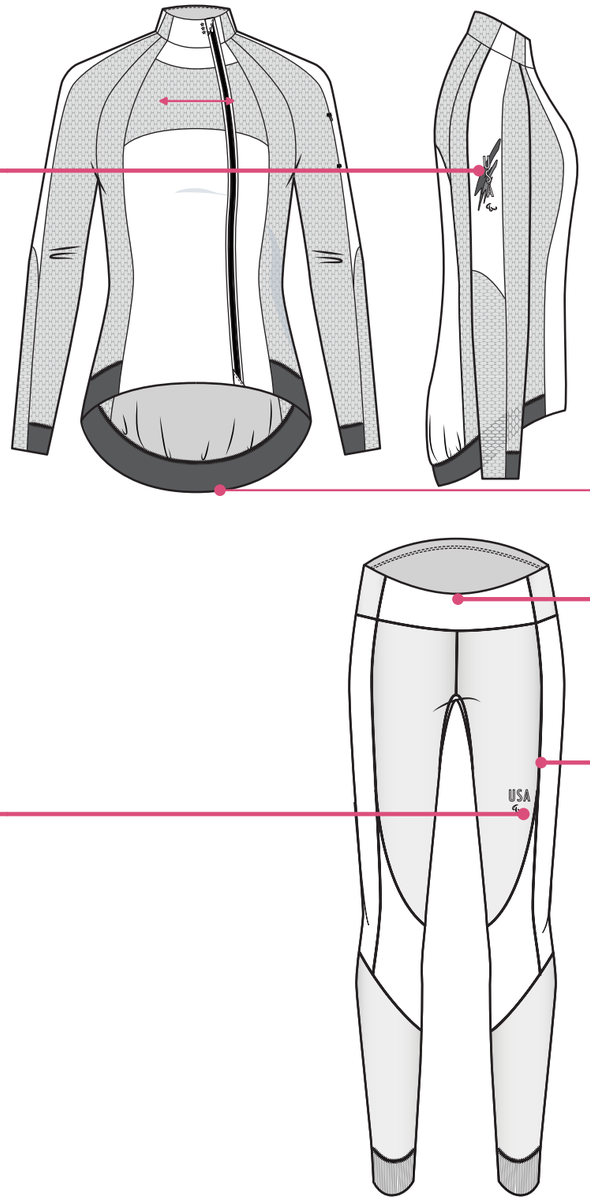


ASYMMETRIC ZIPPER
_ WATERPROOF METAL ZIPPER
_ PREVENTS IRRITATION AT CHIN & NECK

STRETCH PANELING
_ ALLOWS SHOULDER MOBILITY & TIGHT FIT WITHOUT SACRIFICING COMFORT

ZIP CARD & KEY POCKET
_ BONDED POCKET BAG
_ MINIMAL & DISCREET STORAGE

ERGONOMIC ELBOW PANEL
_ STRETCHES TO ALLOW ELBOW BEND

DOUBLE ENDED ZIPPER GARAGE
_ PROTECTS FROM IRRITATION AT CHIN & WAIST

BANDED HEM & SLEEVE CUFF
_ ALLOWS FOR TIGHT FIT AGAINST HIP & WRIST FOR OPTIMAL FIT IN CHAIR

CONTOURED WAISTBAND & HEM
_ LONGER IN THE BACK & SHORTER IN FRONT TO ACCOMODATE FORWARD LEAN

SHIFTED SIDE SEAM
_ MOVES SEAM AWAY FROM PRESSURE & CHAFING OF CHAIR

ANKLE ZIPPER
_ EASIER DONNING & DOFFING FOR PARAPLEGIC ATHLETES

RIBBED CUFF
_ ALLOWS FOR TIGHTER FIT AT ANKLE

JACKET

MATERIALS:

GORE TEX™ 1-WAY STRETCH
_ BREATHABLE WEATHER PROTECTION
_ ALLOWS FOR TIGHTER FIT & IMPROVED MOBILITY

NEOPRENE STRETCH
_ LASER CUT EDGES
_ TIGHT FIT AGAINST BODY

GORE TEX™ WOVEN
_ BREATHABLE WEATHER PROTECTION

CONSTRUCTION:
_ CUT & SEWN WITH SERGED OVERLOCK STITCHING
_ SEAM SEALED FINISH
_ HEAT PRESS GRAPHICS
_ BONDED HEM SLEEVE FINISH

LEGGINGS

MATERIALS:

STRETCH WOVEN POLYESTER
_ WATER REPELLANT & WINDPROOF
_ STRETCHABLE & TIGHT FITTING

SPANDEX/POLYESTER KNIT
_ 4-WAY STRETCH
_ SLICK FINISH ALLOWS ATHLETES TO SLIP INTO CHAIRS EASILY

RIB KNIT
_ 4-WAY STRETCH SPANDEX/POLYESTER
_ SLICK FINISH ALLOWS ATHLETES TO SLIP INTO CHAIRS EASILY

CONSTRUCTION:
_ CUT & SEWN WITH FLATLOCK STITCHING
_ HEAT PRESS GRAPHICS

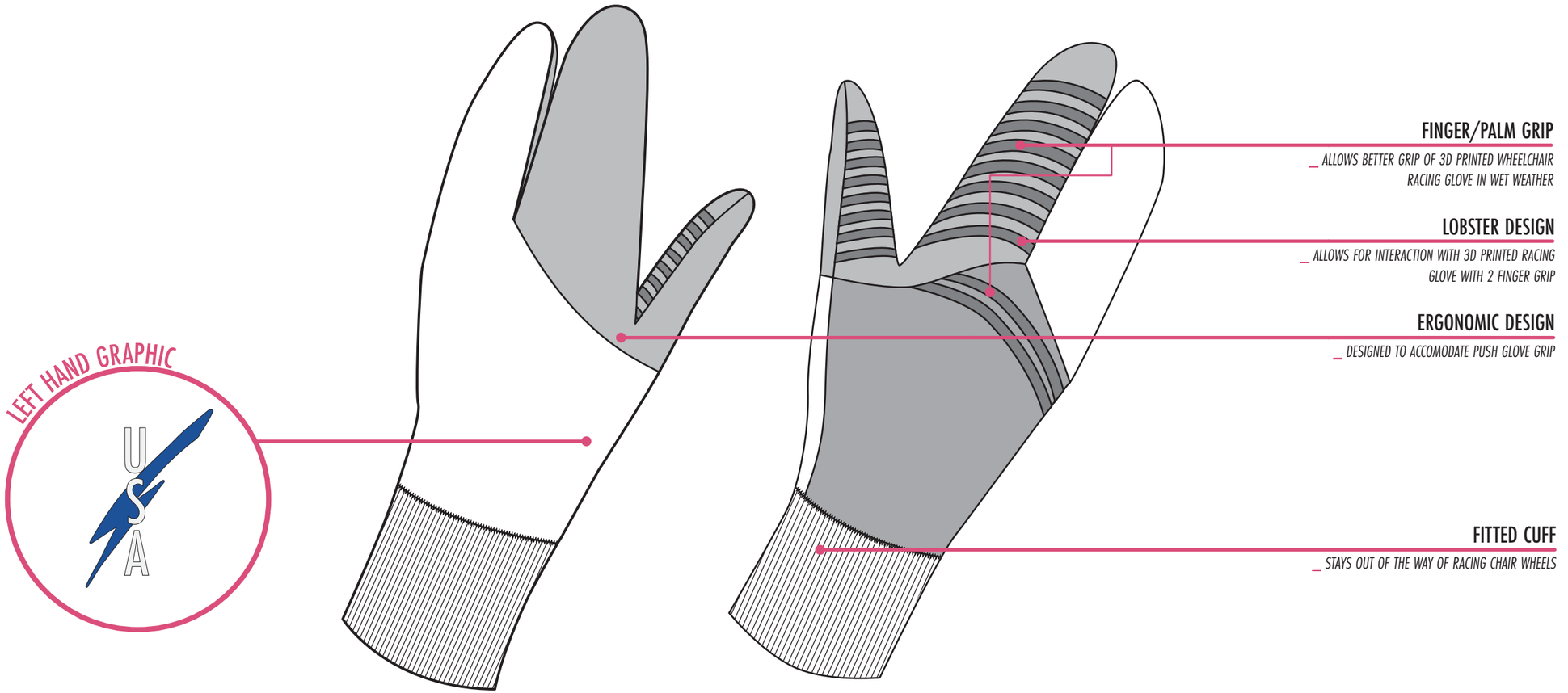
VELOX *RAIN JACKET*

THE VELOX RAIN JACKET ALLOWS FULL RANGE OF MOTION WHILE ALSO PROVIDING BREATHABLE WEATHER PROTECTION. A DISCREET ARM POCKET SUPPLIES SMALL ITEM STORAGE WITHOUT ADDING BULK.

VELOX *WEATHERPROOF LEGGING*

THE VELOX WEATHERPROOF TRAINING LEGGINGS OFFER A SMOOTH SILHOUETTE WITH BODY MAPPED WEATHER PROTECTION WHERE IT'S NEEDED. ANKLE ZIPPERS & A RIBBED CUFF OFFER EASY ON & OFF, AS WELL AS A TIGHT FIT.

VELOX *TEAM USA THERMAL LOBSTER MITT*



FINGER/PALM GRIP
_ *ALLOWS BETTER GRIP OF 3D PRINTED WHEELCHAIR RACING GLOVE IN WET WEATHER*

LOBSTER DESIGN
_ *ALLOWS FOR INTERACTION WITH 3D PRINTED RACING GLOVE WITH 2 FINGER GRIP*

ERGONOMIC DESIGN
_ *DESIGNED TO ACCOMODATE PUSH GLOVE GRIP*

FITTED CUFF
_ *STAYS OUT OF THE WAY OF RACING CHAIR WHEELS*

MIT

MATERIALS:

GORE TEX™ WOVEN & WICKING FLEECE
_ *BREATHABLE WEATHER PROTECTION*
_ *WARMTH ON EXPOSED FINGERS*

BRUSHED BACK POLYESTER/SPANDEX
_ *TIGHT FITTING THERMAL PROTECTION*
_ *MOISTURE WICKING FOR ATHLETE COMFORT*

RIB KNIT
_ *POLYESTER/SPANDEX KNIT*
_ *ALLOWS TIGHT FIT AROUND WRIST*

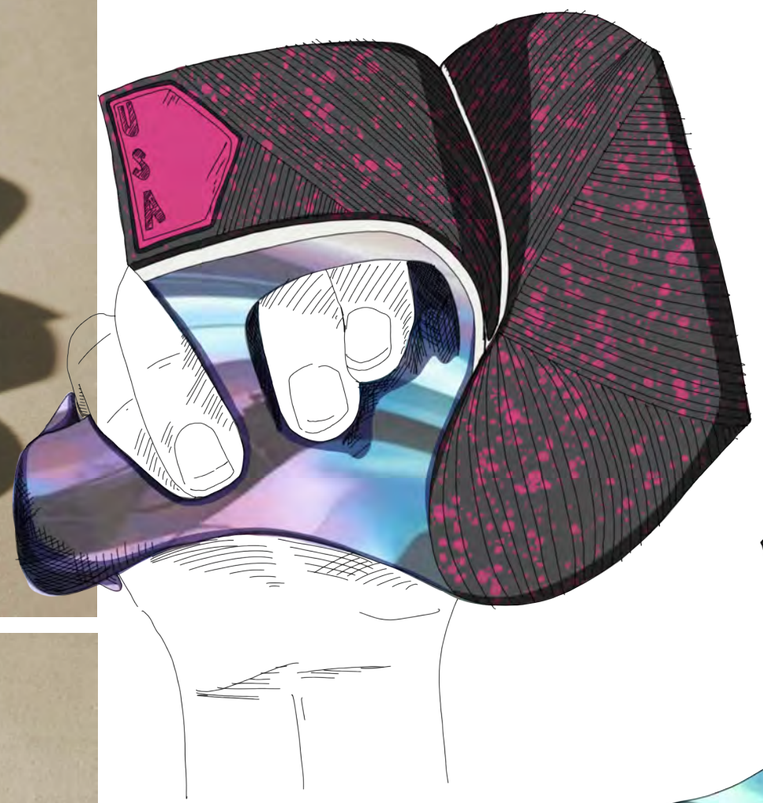
CONSTRUCTION:

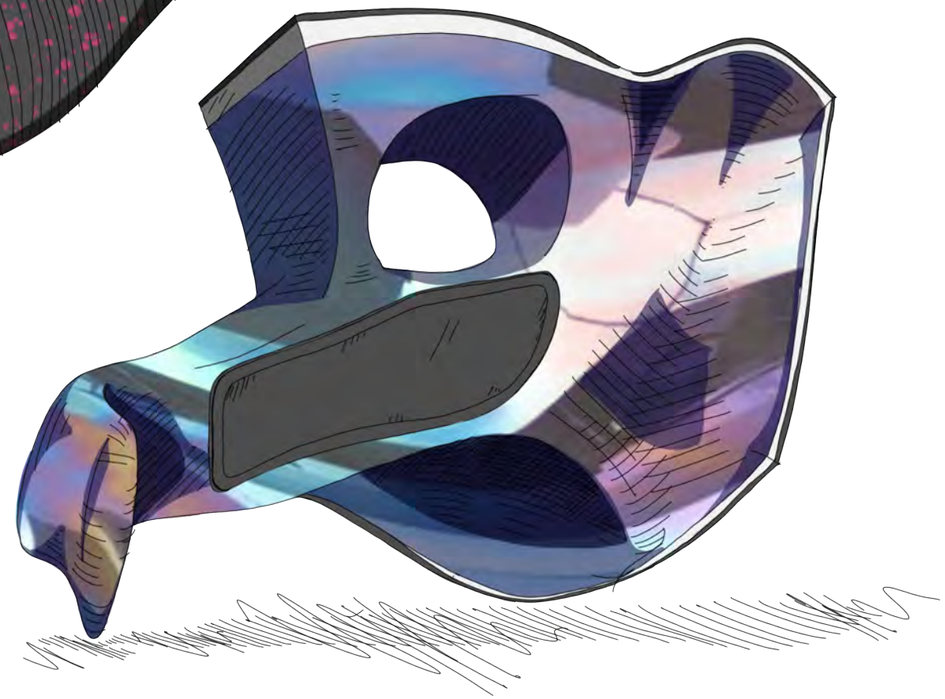
_ *CUT & SEWN WITH LOCKSTICH & OVERLOCK STITCHING*
_ *HEAT PRESS GRAPHICS*
_ *SILICON GRIP LINES*

VELOX *LOBSTER MITT*

THIS LOBSTER MITT IS DESIGNED TO INTERACT WITH THE RIGID 2-FINGERED PUSH GLOVE. A BALANCE OF STRETCH PANELING & THERMAL PROTECTION KEEP ATHLETES' HANDS WARM & DRY IN CHILLY CONDITIONS

VELOX *PUSH GLOVE*





VELOX *TEAM USA PUSH GLOVE*

FOAM PROTECTED HITTING SURFACE

MINIMIZE IMPACT INJURY& ALLOW A MORE SECURE GRIP ON THE PUSH RIM

TREAD ENHANCED VIBRAM MEGAGRIP™ RUBBER

ENHANCE TRACTION IN HUMID OR WET CONDITIONS & LEND A PERFORMANCE AESTHETIC

SLEEK & FLUID GEOMETRY

PROVIDE A PERFORMANCE AESTHETIC TO THE PIECE & ELEVATE PERCEIVED INTEGRITY OF THE GLOVE

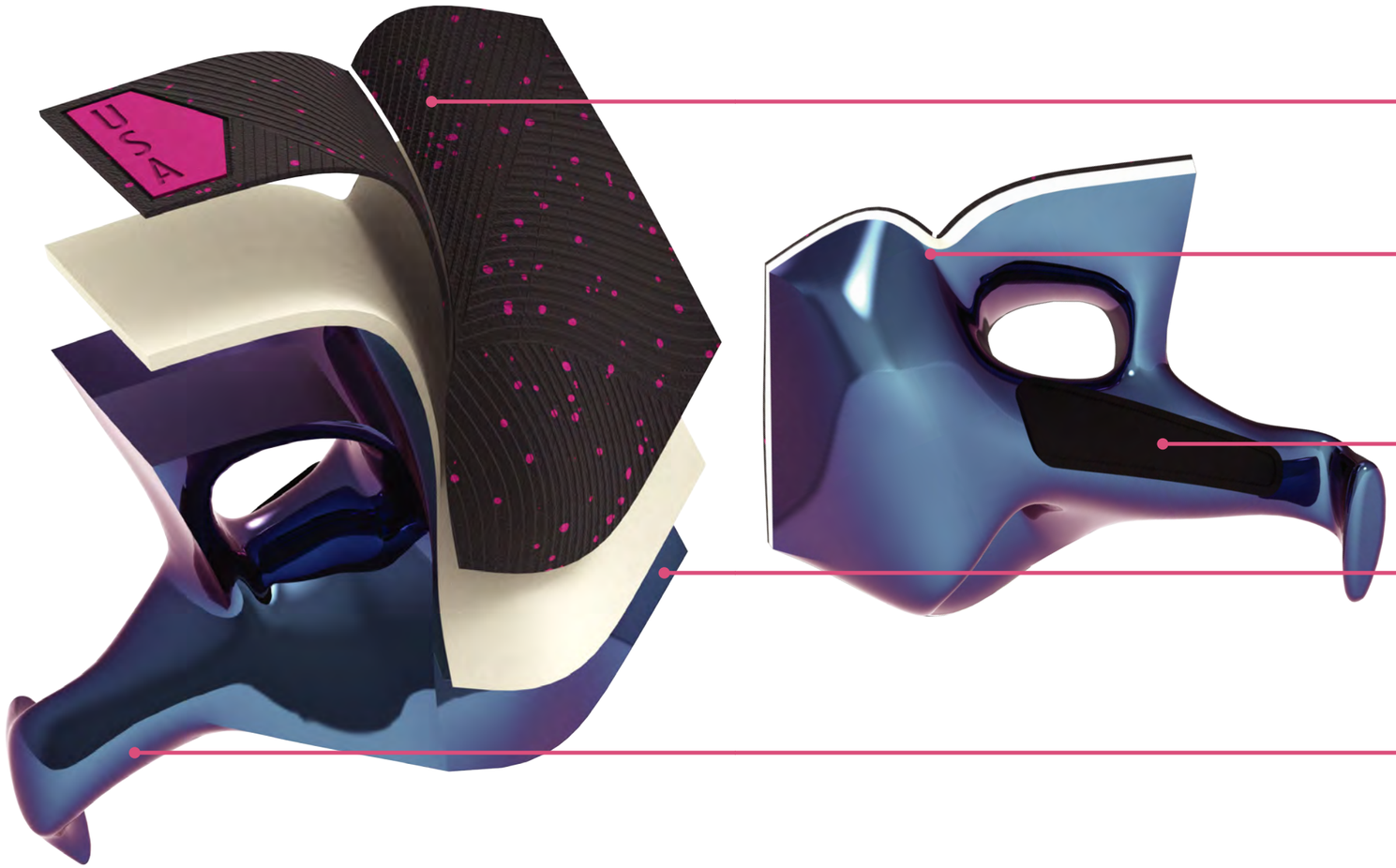
FLARED THUMB SHAPE

LESSEN FOREARM PRONATION AT THE END OF RACING STROKE TO MINIMIZE ULNAR DEVIATION, KEEP THE WRIST CLOSER TO NEUTRAL, & MINIMIZE INJURY RISK OVER TIME

METALLIC FINISHES

FLICKERS IN SUNLIGHT & STADIUM LIGHTING TO PROVIDE VISUAL INTEREST AS THE ATHLETE MOVES

VELOX *PUSH GLOVE*



TREAD PATTERN
_ *LENDS PERFORMANCE AESTHETIC*
_ *ENHANCES TRACTION ON PUSH RIM*

GROOVED SHAPE
_ *EFFICIENT FORCE TRANSFER FROM ATHLETE TO PUSH RIM*

GRIP
_*IMPROVED GRIP IN HUMID CONDITIONS*

FLARED THUMB RELEASE
_*REDUCES FOREARM PRONATION TO MINIMIZE WRIST OVERUSE INJURY*
_*INCREASED SURFACE AREA IS BENEFICIAL FOR HILL CLIMBING DUE TO LONGER CONTACT TIME*

ERGONOMIC HANDLE
_*ERGONOMIC FIT, EXCELLENT FORCE TRANSFER*

PUSH GLOVE

MATERIALS:

CARBON FIBER/NYLON COMPOSITE
_ *REPONSIVE FORCE TRANSFER FROM ATHLETE TO PUSH RIM*

CONSTRUCTION:
_ *3D SCAN MOLDED GLOVES OF ATHLETE*
_ *COMBINE WITH BODY OF VELOX GLOVE*
_ *3D PRINTED*

EVA FOAM
_ *PROVIDES RESPONSIVE CUSIONING TO WRIST JOINTS*
_ *ALLOWS FOR BETTER TRACTION WITH FOAM DEFORMATION*

CONSTRUCTION:
_ *INJECTION MOLDED*

VIBRAM® MEGAGRIP RUBBER
_ *UNPARALLELED TRACTION IN WET & DRY CONDITIONS*
_ *ENHAANCES DURABILITY OF GLOVE*

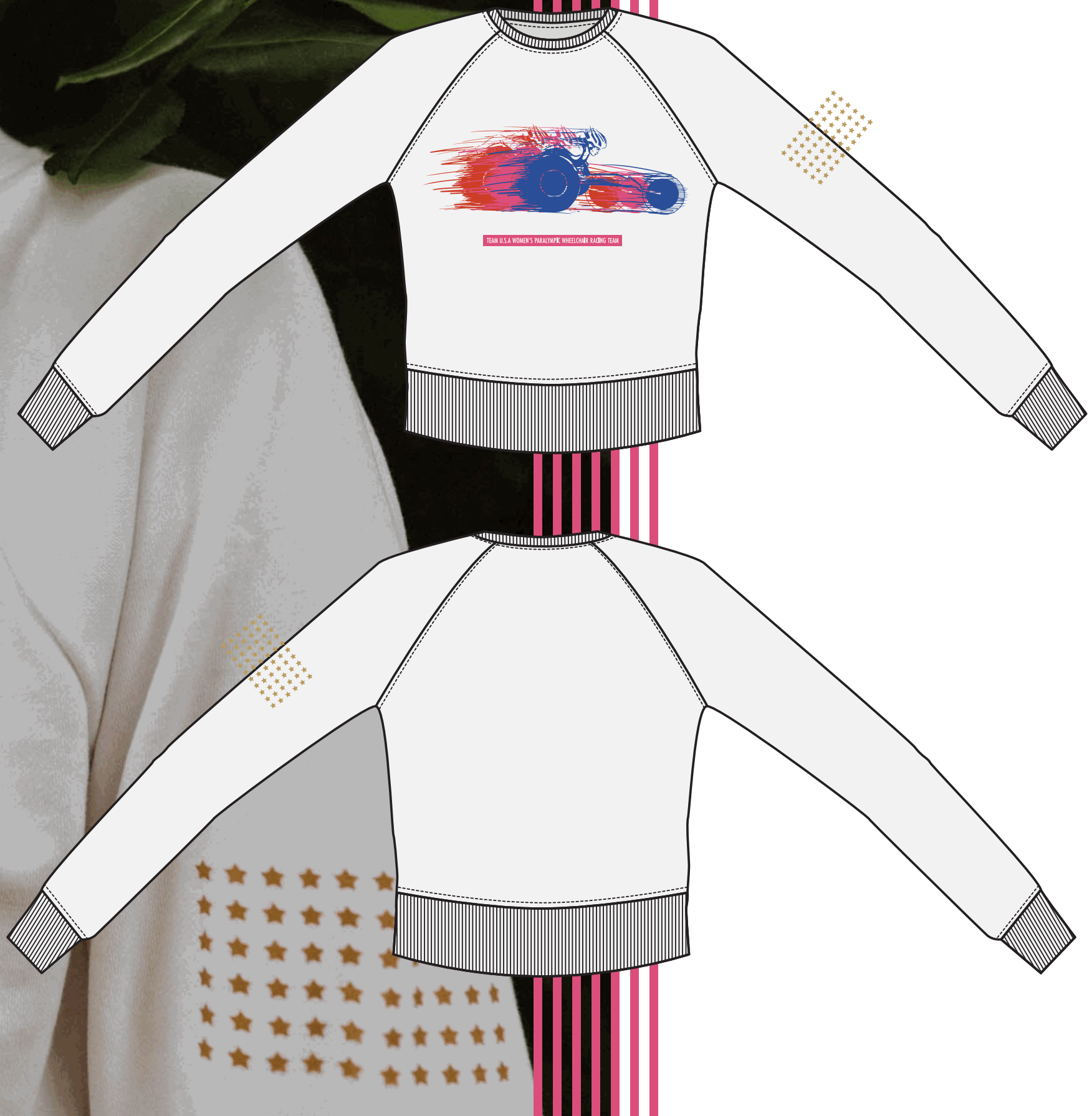
CONSTRUCTION:
_ *MOLDED RUBBER*

SOFT SHEET RUBBER
_ *PREVENTS DROPPED GLOVES*

CONSTRUCTION:
_ *STAMPED SHEET RUBBER*

VELOX *KEEPSAKE SWEATSHIRT*

A CLASSIC COTTON CREW NECK TO BE WORN FOR DECADES
& PASSED ON, A REMINDER OF FAST RACES & GOOD TIMES
AT THE PINNACLE OF AN ATHLETIC CAREER



VELOX *PACKAGING*

HANG TAG

Designed for the US Team, "America's Best"

VELOX RACING KIT

Ergonomic Fit: *Contoured to the working position of wheelchair racing*

Body Mapped Ventilation: *Laser cut venting where racers need it most*

Protective Silhouette: *Kevlar blended arm sleeves and full length leggings to protect against chafing*

VELOX WEATHERPROOF TRAINING KIT

Ergonomic Fit: *Contoured to the working position of wheelchair racing*

Gore Tex™ Fabrics: *Breathable weather protection to keep athletes comfortable & dry*

Stretch Paneling: *Moves with you to allow full mobility for optimal performance*

VELOX RECOVERY CREW

Perfect for travel, cool down, and lounge, the Velox recovery crew is the type of garment that will wear in over time. A classic crisp cotton will soften more and more with every wash. This classic piece will get passed on and carry memories of the Paralympic games for years to come.

VELOX IS A LATIN WORD MEANING "SWIFT"

The Velox collection is the first performance apparel collection designed in accordance with the unique ergonomic, physiological, and mobility needs of the elite women's wheelchair racing athlete. Extensive research & athlete insights went into creating garments designed to disappear and allow athletes to focus on performance.

Designed for the US Team, "America's Best"

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VELOX *PACKAGING*

PUSH GLOVE BOX

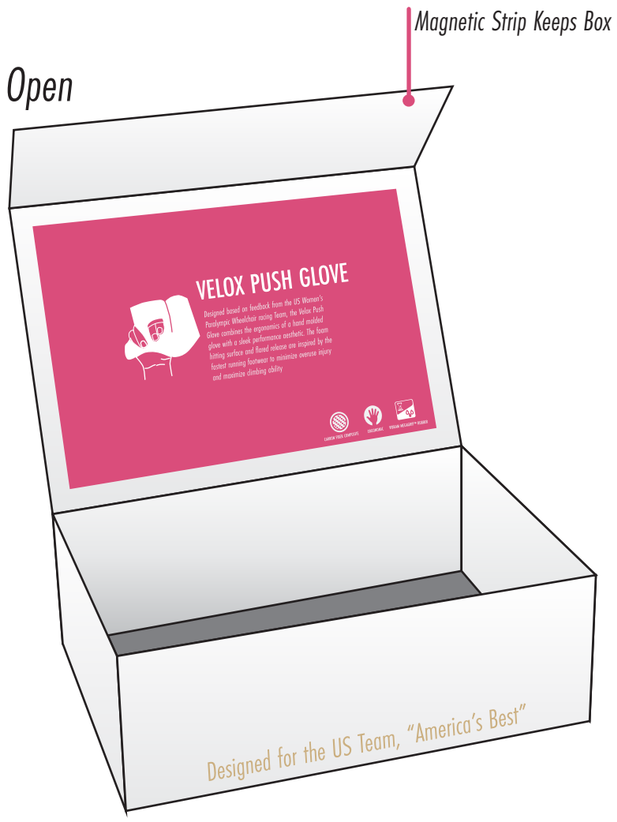
Closed

Label with athlete name

Top

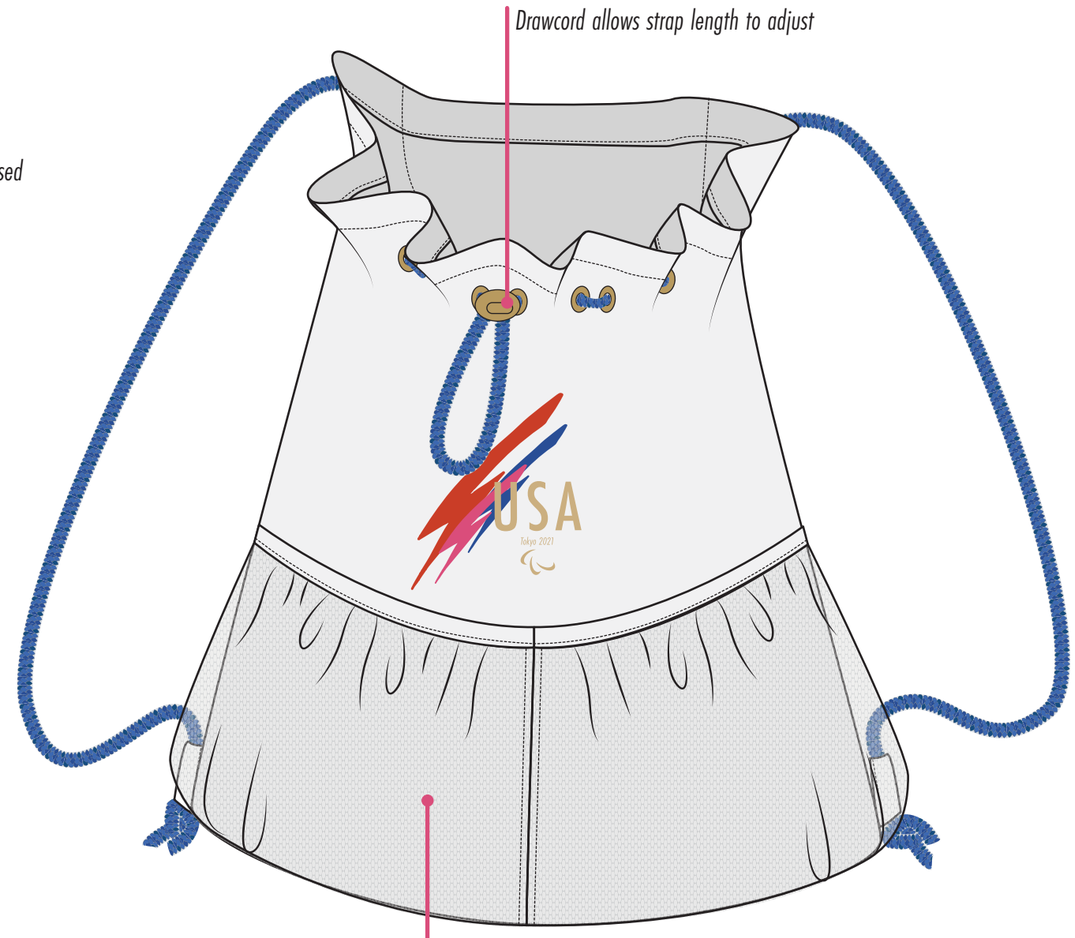
Open

Magnetic Strip Keeps Box Closed



COMPETITION BAG

Drawcord allows strap length to adjust



Elastcicized mesh glove pocket

ATHLETE OUTCOMES

"WHEN SARAH CONTACTED ME ABOUT RESEARCHING THE UNIQUE APPAREL NEEDS OF WOMEN WHEELCHAIR RACERS, I HAD SOME DOUBTS THAT THE PROJECT WOULD BE VERY FRUITFUL.

HOWEVER, TO MY SURPRISE THE SMALL INTRICACIES THAT MAKE OUR SPORT SO UNIQUE CAME TO MIND, AND THE WAYS THAT CURRENT OPTIONS CONTINUED TO FALL SHORT WERE NUMEROUS. EXAMPLES ARE RAINPROOF JACKETS WITHOUT HOODS THAT NEED TO BE BOTH LIGHTWEIGHT & ENABLE MOBILITY; OPTIONS TO KEEP EXPOSED FINGERS WARM BUT NOT IMPACT A TIGHT FITTING RACING GLOVE; HIGH NECK SINGLETS; ANKLE COVERAGE; MATERIAL THAT CAN SLIDE INTO AN EXTREMELY TIGHT FITTING FRAME; AND MORE. I'M SO THANKFUL FOR THOSE WHO LOOK OUTSIDE THE BOX TO OPTIMIZE PERFORMANCE IN WAYS ATHLETES MIGHT NOT EVEN THINK OF—INNOVATION FOR BETTERMENT."

- SUSANNAH SCARONI

THANK YOU!

ATHLETE INSIGHTS:
SUSANNAH SCARONI
ARIELLE RAUSIN
YEN HOANG
ADAM BLEAKNEY

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GORE TEX
WSI SPORTS OF MN

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