Prossima

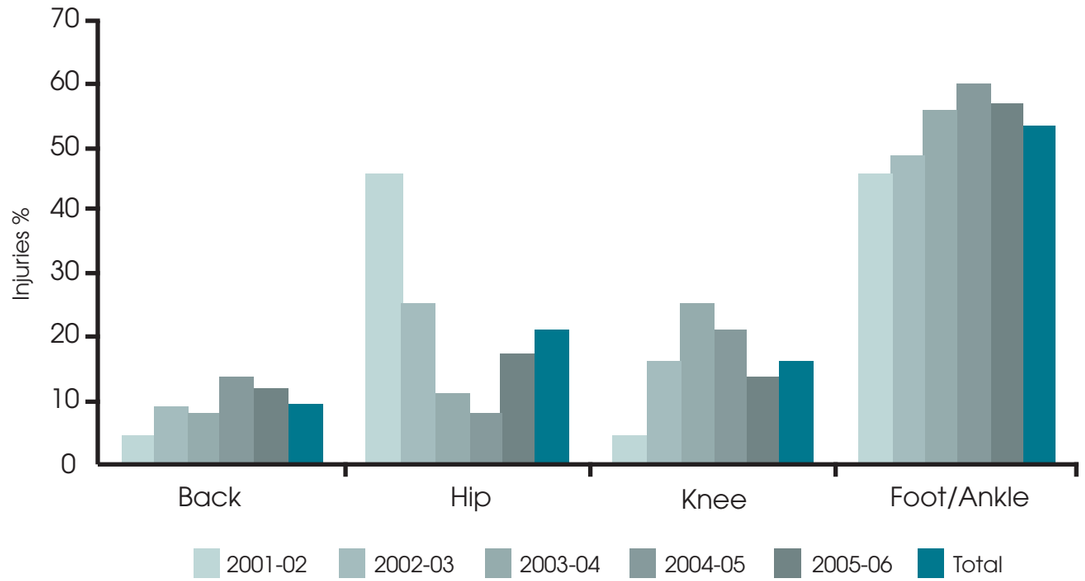
Dance footwear that assists in injury prevention

Table of Contents

Framing the Problem

The current dance footwear market leaves a lot to be desired. The solutions most commonly used leave dancers vulnerable to injury, in an already dangerous sport.

Distribution of Dance Injuries by Musculoskeletal Region over a 5-Year Study Period



"Eight in 10 dancers in the United Kingdom have at least one injury a year that affects their ability to perform"

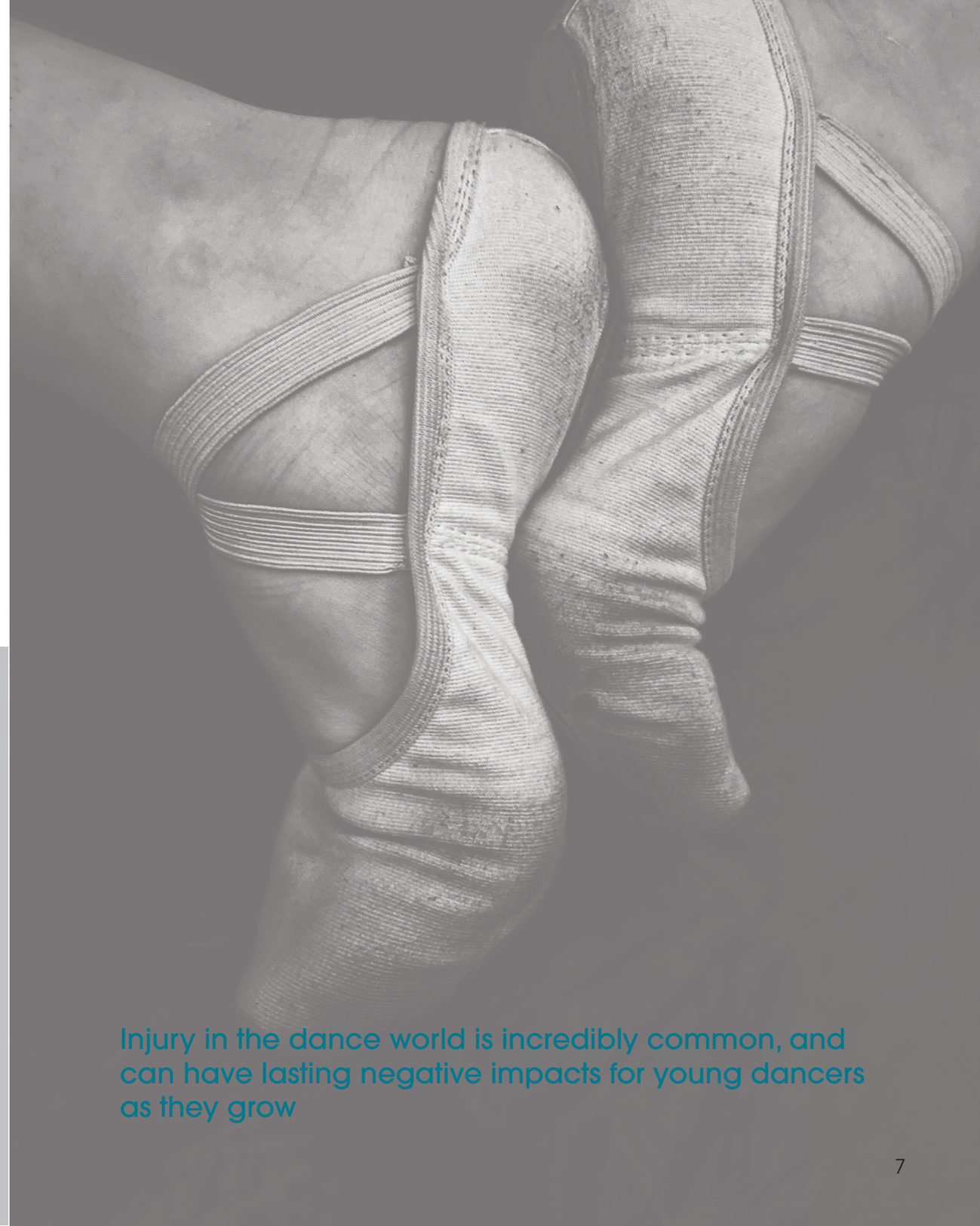
- The Business of Medicine Journal, "Eight in 10 dancers have an injury each year, survey shows"

"Professional dance companies have reported that as many as 67% to 95% of their dancers are injured on an annual basis... In ballet, the greatest proportion of injuries is reported to occur in adolescent dancers 12 to 18 years of age."

- Journal of Orthopaedic & Sports Physical Therapy, "Injury Patterns in Elite Preprofessional Ballet Dancers and the Utility of Screening Programs to Identify Risk Characteristics"

"The risk of injury is greatest during a young dancer's growth spurt. This is usually between the ages of 8 to 12 for girls and 10 to 14 for boys"

- Children's Hospital of Colorado, "Dance"



Injury in the dance world is incredibly common, and can have lasting negative impacts for young dancers as they grow

Common Dance Injuries

Injury	Causes	Outcomes	Treatments
Achilles Tendinitis	repetitive or intense strain on the Achilles tendon, Running in worn-out shoes	can weaken the tendon, making it more vulnerable to a tear (rupture) — usually requires surgical repair	rest, pain medication, physical therapy, shoe inserts, surgery
Posterior Ankle Impingement	occurs due to inadequate rehabilitation following an acute ankle injury	sharp pain when toes are pointed, chronic ache	rest, pain medication, compression, physical therapy, surgery
Ankle Sprain	occurs when you roll, twist or turn your ankle, prior injury, poorly fitted shoes	chronic ankle pain, chronic ankle joint instability, arthritis in the ankle joint	rest, ice, pain medication, compression, crutches, brace, boot, cast, PT, surgery
Bunions	tight fitting shoes (in toe area), previous foot injury	toe bump, swelling, pain, bursitis, arthritis, metatarsalgia	padding, shoe insert, surgery
Trigger Toe	dancing en pointe	swelling, pain, rupture, joint lock, end of dance career	rest, PT, padding, stretching
Sesamoiditis	overuse of toe tendons, repeated trauma	ball of foot pain, bruising, difficulty moving big toe	rest, ice, wearing soft sole shoes, brace, taping of toe
FHL Tendinopathy	repetitive or prolonged loading of the FHL tendon	dull ache, swelling, ankle clicking, locking of big toe	rest, PT, stretching and massaging, splint, surgery
Sever's Disease	repetitive stress to the heel	Pain in heel, stiffness	rest, heel pads, elevated heel shoes, stretching, NSAIDs
Shin Splints	overworking shin muscles, tendons and bone tissue	Pain, tenderness, stress reaction, stress fracture	rest, ice, shock abs. insoles, cushioning, arch support

Many dance injuries occur due to repetitive training activities, lack of proper recovery measures, and poorly fitted footwear.

The resulting injuries can cause a wide range of issues including chronic pain, joint locking, and stress fractures.

Treatment options involve traditional measures such as rest, ice, physical therapy, and even surgery. However, they also include options such as shoe inserts, compression, wearing soft soled shoes, and bracing.

With so many of these treatment options widely available, why aren't we incorporating them into our products as preemptive measures?

Expert Opinions

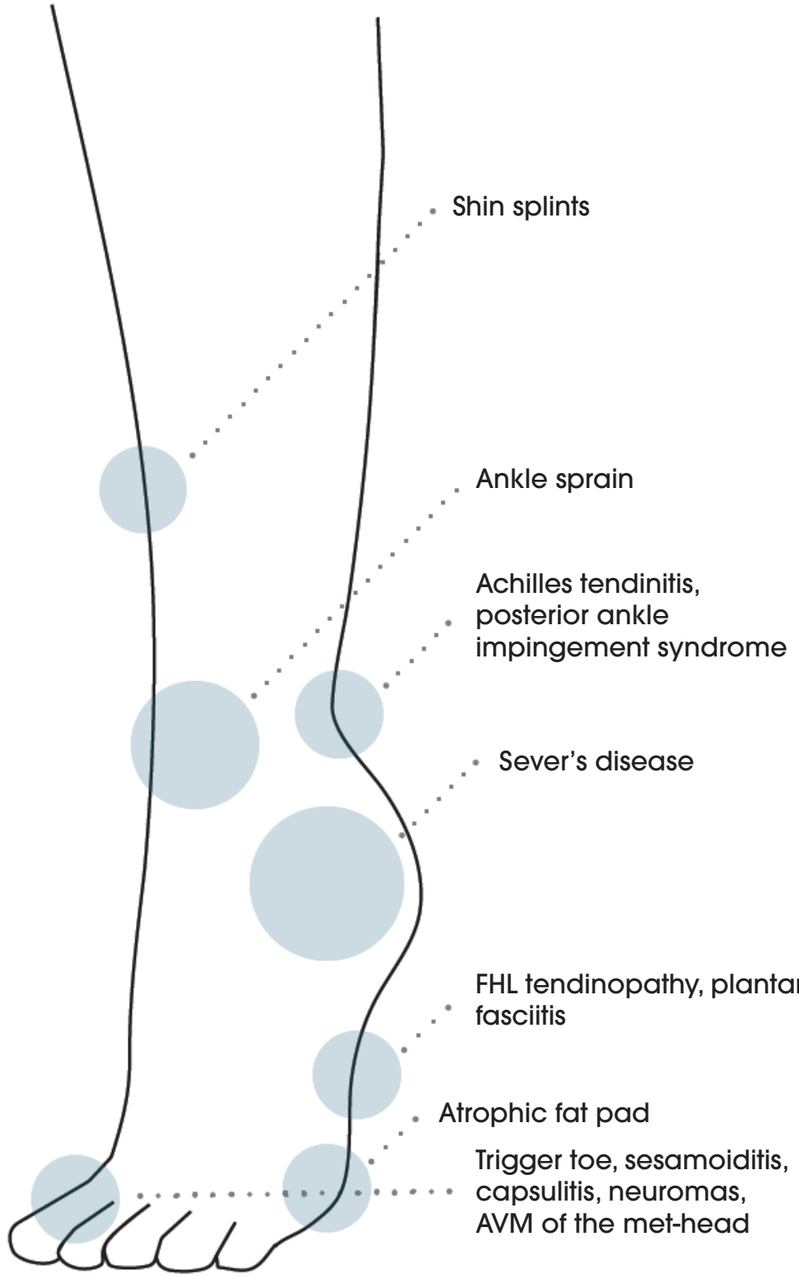
I spoke with two podiatry specialists to verify my research and gain further insight. This helped me understand which injuries were both common and most necessary to address.

Jared Remmers

DPM Assistant Director Podiatric Medicine and Surgery Residency Program
Legacy Health Systems - Portland, Oregon

Craig Skalla

DPM Podiatry Specialist
SouthCoast Medical Group - Savannah, Georgia

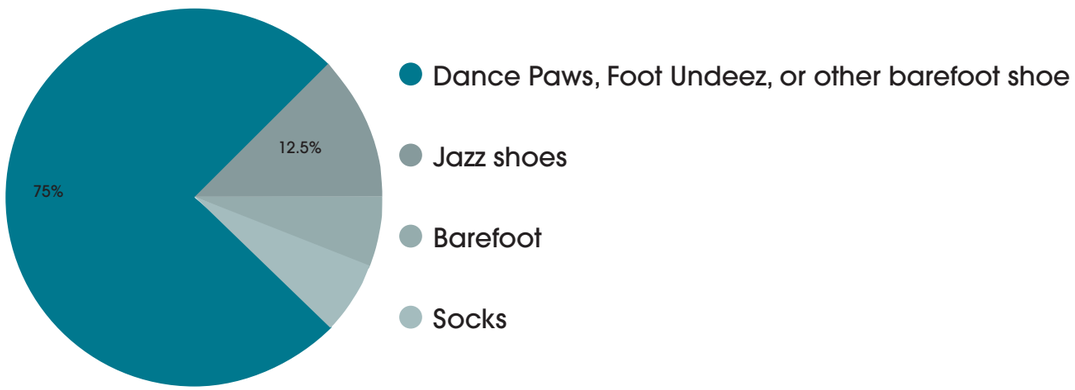


My updated list of common dance injuries is depicted above. The injuries shown occur frequently, and can also be positively impacted by improved footwear

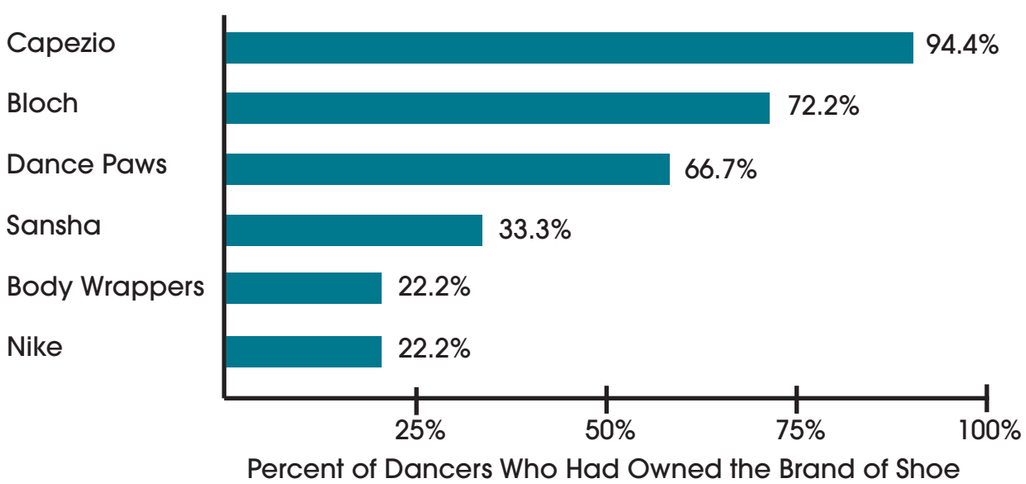
Learning the Market

I conducted a survey online of 47 dancers as well as some mothers of dancers. Through the questions I aimed to verify user and consumer product preferences and features.

What type of footwear do you usually wear for jazz/ lyrical/contemporary/modern?



Which brands of jazz/lyrical/contemporary shoes have you previously owned?



Elegant and Modern

The most popular form of footwear, the "Dance Paw," is a lightweight mesh and suede sleeve for the ball of the foot. It is considered modern and efficient in the dance world.

For the Weak

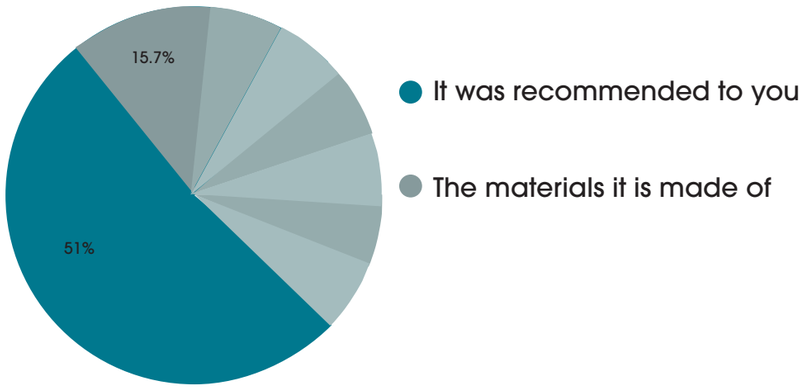
Jazz shoes are a more full coverage footwear option, while still staying lightweight. Unfortunately, these shoes are often seen as a crutch.

Clunky and Dated

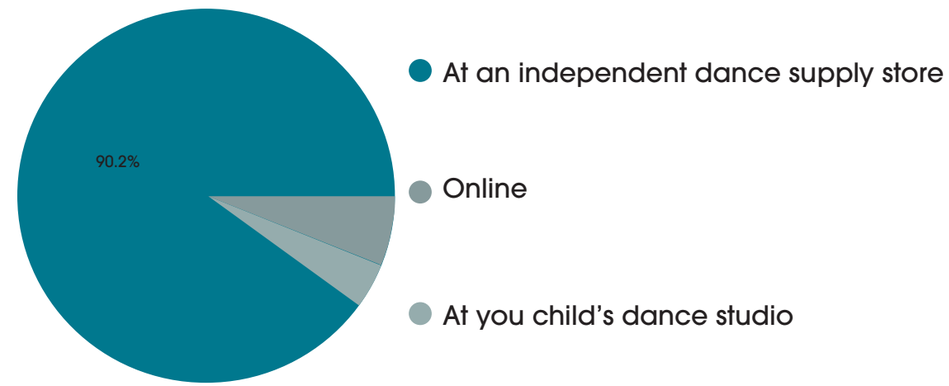
The dance sneaker is the most unpopular form of dance shoe. It is outdated in terms of look and technology, and is viewed as a product for aging dancers.

Understanding the Market (Continued)

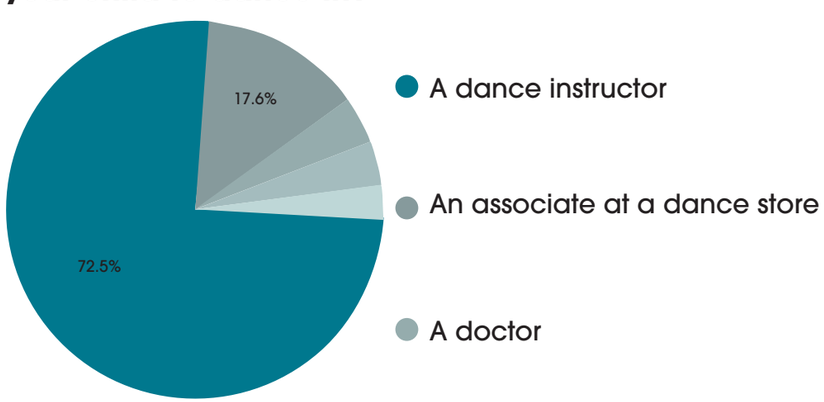
What is the most important factor in why you buy a dance shoe for your child?



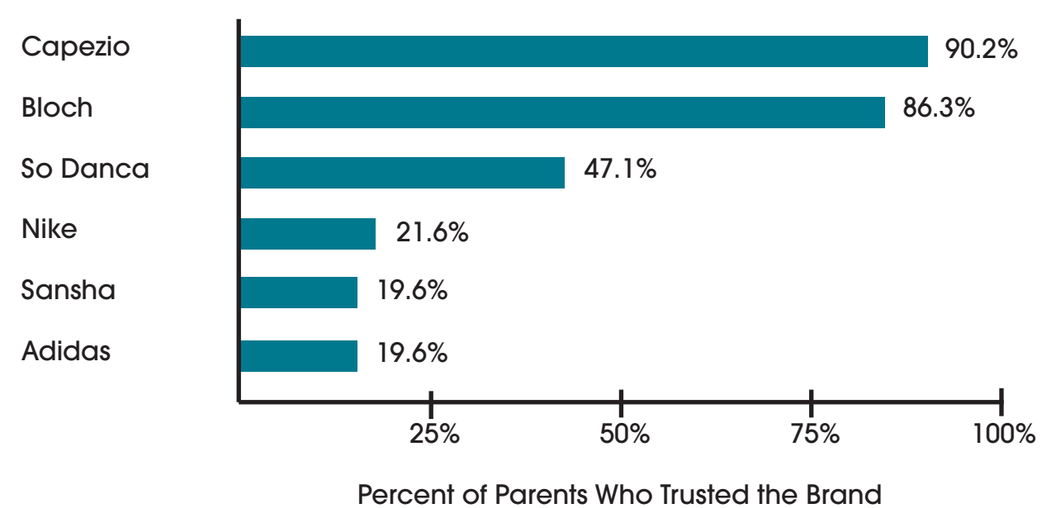
Where do you most often purchase dance shoes for your child?



Whose advice are you most likely to take when buying shoes for your child to dance in?

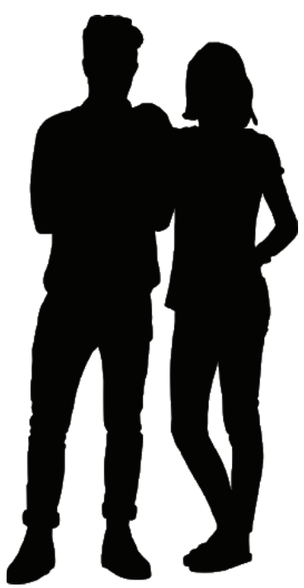


Which brands of dance shoes do you trust most?



Market Demographic

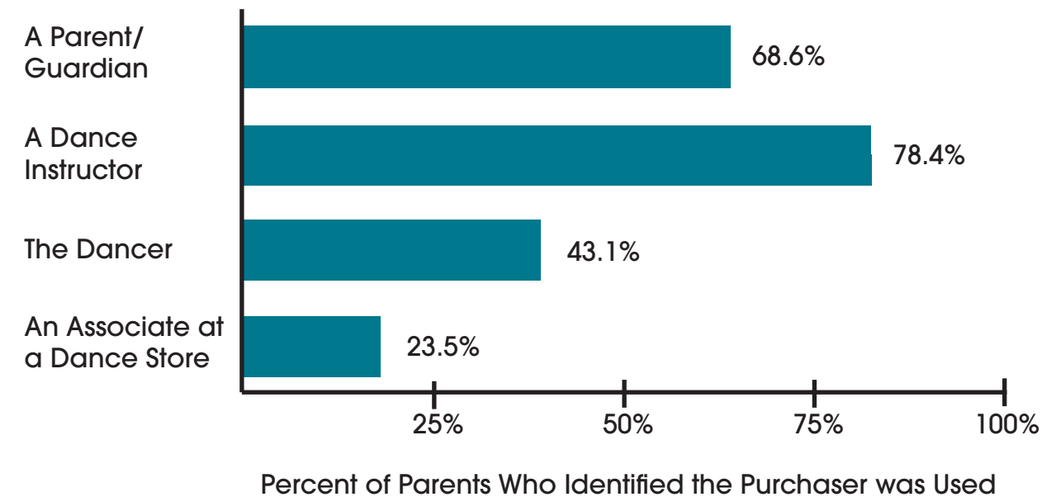
The user group for an injury prevention footwear solution is dancers ages 10 to 16. This is the age range where dancers are most at risk because they are still growing, and also the age range where there is the largest number of dancers



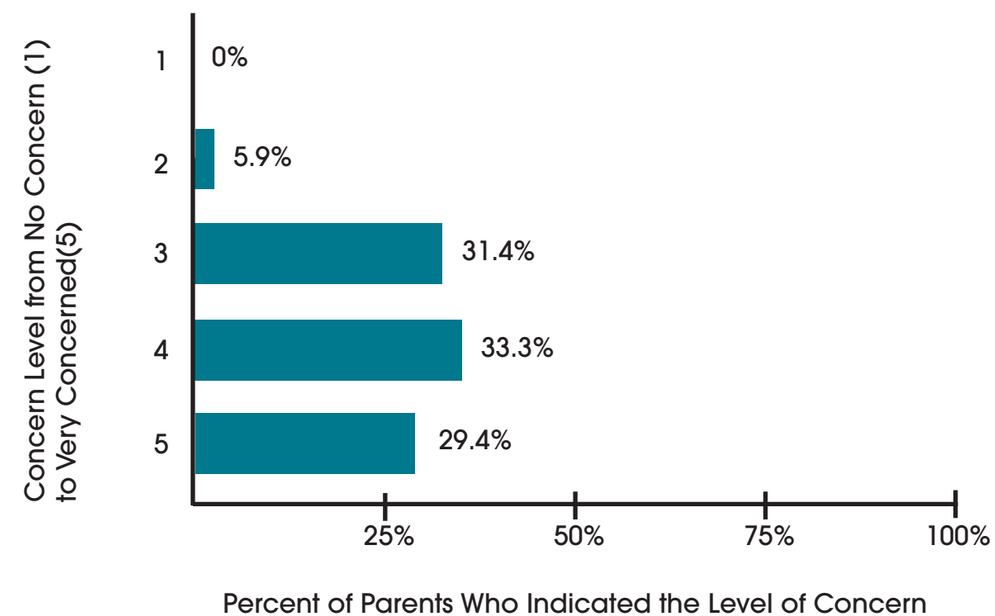
The consumer group, however, is parents or guardians of dancers. This is because at the age of 10 to 16 the majority of parents are still in complete control of their child's finances.

Product designs need to keep both stakeholder groups into account.

Who makes the purchasing decisions for your dancer's footwear?



How concerned are you about potential health injuries or health problems your child may face as a result of dancing?



Expert Opinions

It was important to receive input from dance professionals involved in all areas of the industry. Dance studio owners, instructors, and supply store owners are all key stakeholders.

Casey Davenport

Dance instructor

"Dance sneaker technology has been at a standstill since 2004"

Kristen Stoller

Dance Studio Owner and Instructor
Owner of Allstar Dance Store

"Dance sneakers are dated looking, too much going on, restrict foot development"

Major Players

The dance footwear market is dominated by dance specific names such as Capezio, Sansha, and Grishko, instead of household names such as Nike. In recent years the large athletic companies have entered the dance market, but have mostly had a poor reception from consumers.

Nike Studio Wrap

Mesh, sandwich mesh, neoprene, flocking, floor grips

All colors

Currently unavailable (available at some resellers)

Adidas Crazymove

Primeknit, rubberized sole, elastic

Black, grey, white

Currently unavailable

New Balance Studio Skin

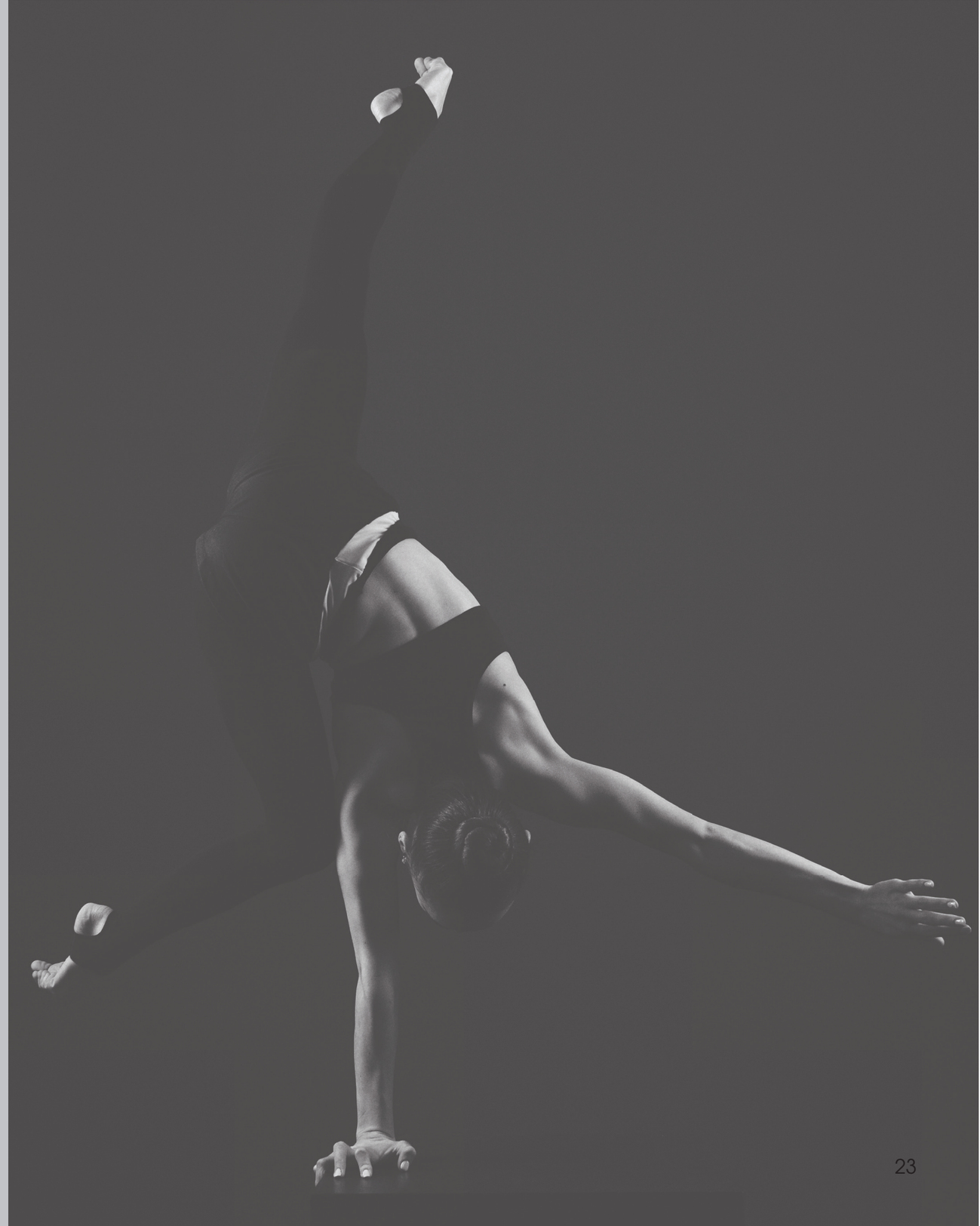
Stretch material, toe padding, odor resistant, silicone grips

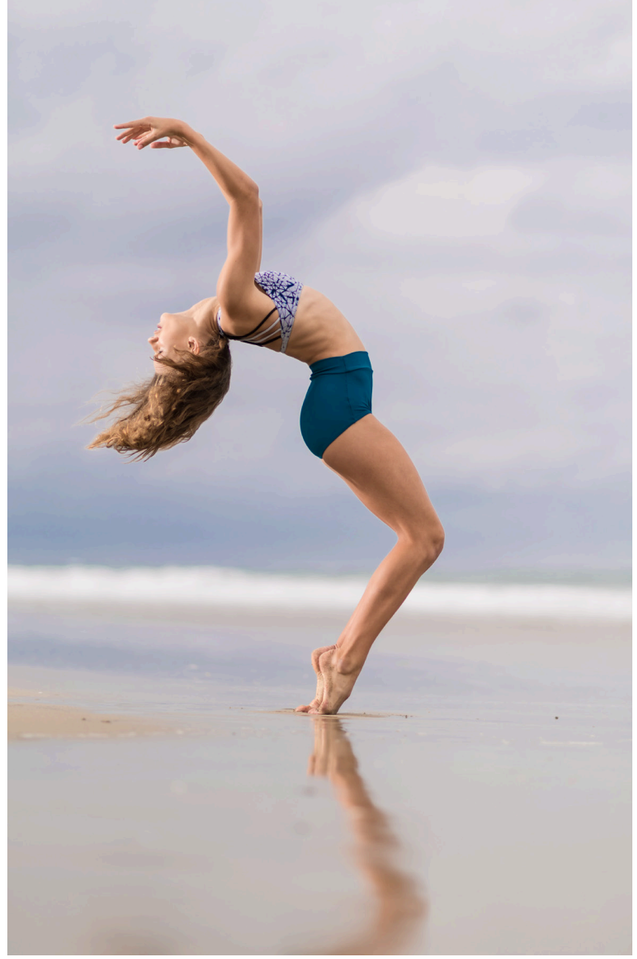
Grey, white

Currently available

The Sport

Dance isn’t a widely understood activity. I had years of first hand experience to guide me, but I needed to understand the science behind it.





Informational Quotes

"Perhaps the most 'abused' feet in the dance business are those of modern dancers, who traditionally work barefoot and need to take extra preventive care of their feet."

- Back Stage East

"Repetitive impact on the foot has been extensively studied... Stress fractures and bursitis (soft tissue swelling over bony prominences and tendon insertions) are the short term effects seen most often. Long term effects believed to be attributed to this, includes ligamentotaxis (stretching out of ligaments), fat pad atrophy (loss of the fatty layer between the skin and the bottom of the foot bones), and osteoarthritis (wear and tear joint degeneration)."

- Jared Remmers
  DPM Assistant Director Podiatric Medicine and Surgery Residency Program Legacy Health Systems - Portland, Oregon

Dance Footwear Demands

There are a few key factors of dancer foot movement that need to be addressed in footwear design.

Full Foot Articulation

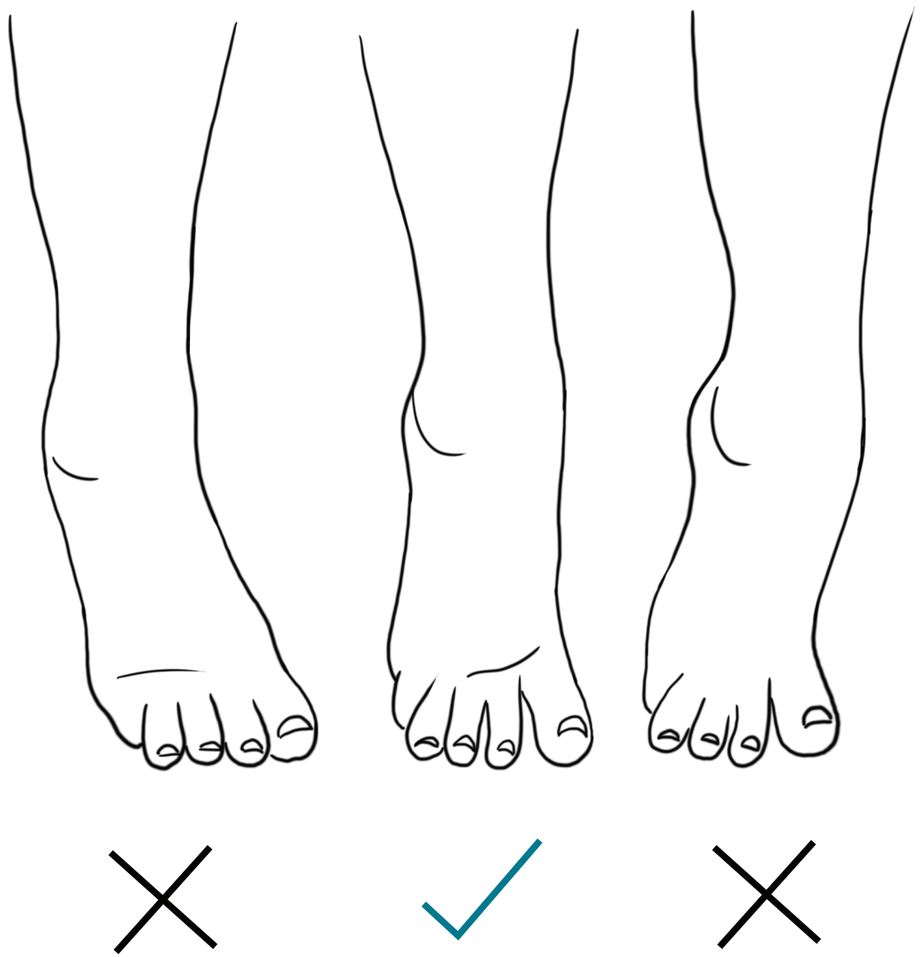
Pointed toes are what separate dancers from cheerleaders and gymnasts. This key element of dance technique requires that footwear allow dancers to fully point through the ankle and toes of the foot.

A split sole design will allow the dancer to fully articulate the foot while still offering protection.

Ankle Strength

While the ankle should be supported to prevent injury, dancers need freedom of movement in order to build up strength to maintain proper placement.

The design should offer support without impeding full range of ankle motion.



Weight Distribution

Dance technique requires weight to be on the balls of he feet at all times, not evenly distributed like in normal life. Additional support is needed to protect this area properly from repeated impact.

Cushioning should be optimized for repeated impact on the balls of the feet.

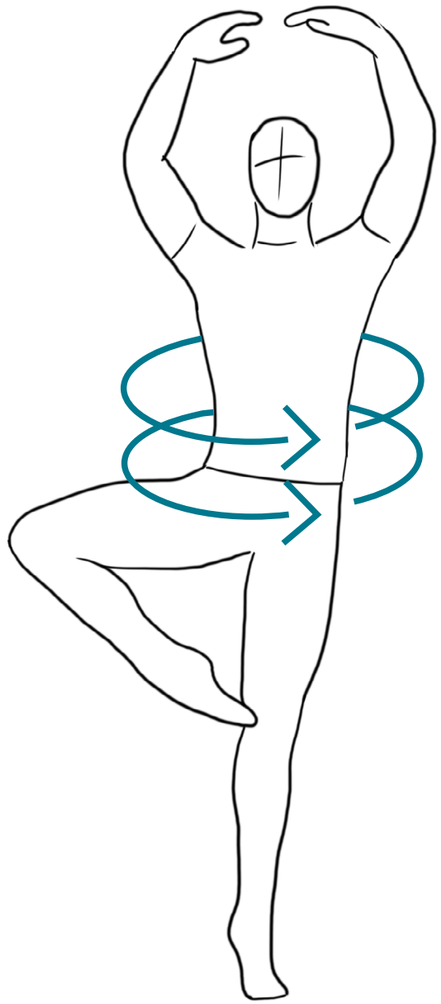
Key Dance Actions

Dancing can be broken into three main action categories: turning, jumping, and balancing. Each activity has it's own requirements it presents for the design.

Turning

In addition to a secure fit in quick side to side movements like other sports, dancers also need proper fit in repeated rotational movements.

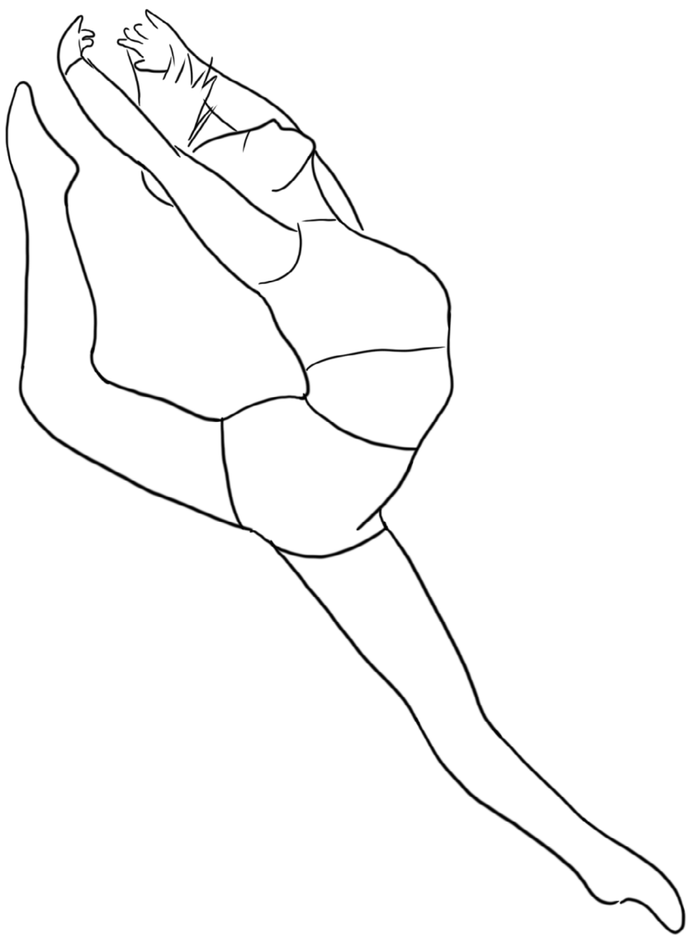
The shoe design needs good lockdown and fit in order to stay secure on the foot during rotation.



Jumping

Modern jazz dance incorporates elements of cheer and gymnastics which put the body under large amounts of strain in terms of flexibility and landing impact.

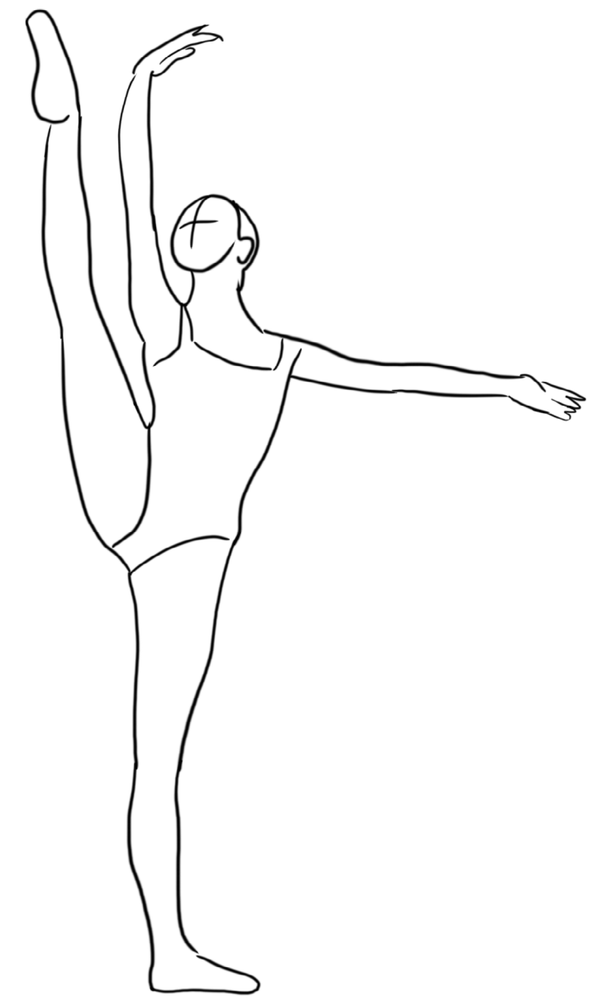
Modern impact reduction methods such as cushioned midsoles and insoles could reduce injury.



Balancing

Stability and control are involved in all aspects of dance, but balances add the additional challenge of “feeling the floor” or finding your balance while remaining in a pose with imbalanced weight.

Sneakers should allow dancers to stay connected to the floor surface while still having proper support.



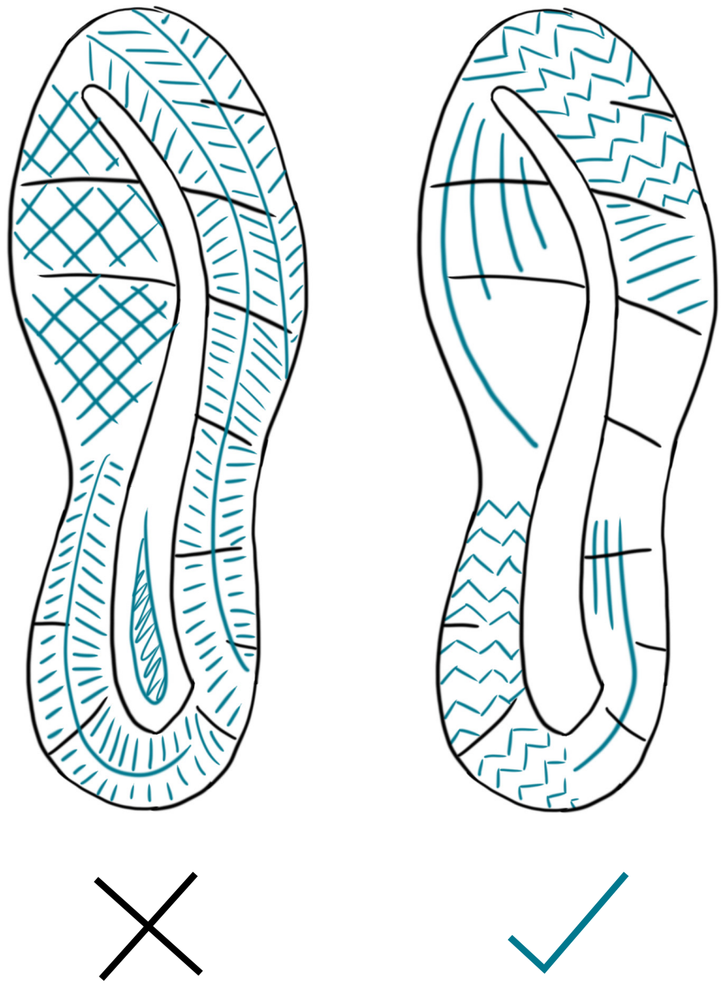
Research Considerations

While dance has not been studied extensively, footwear in general has. Activities such as running and aerobics can give some insight into the footwear considerations needed for repetitive impact.

Traction

According to the Medicine in Science and Sports and Exercise Journal rotational traction needs to be minimized in order to reduce ankle injury.

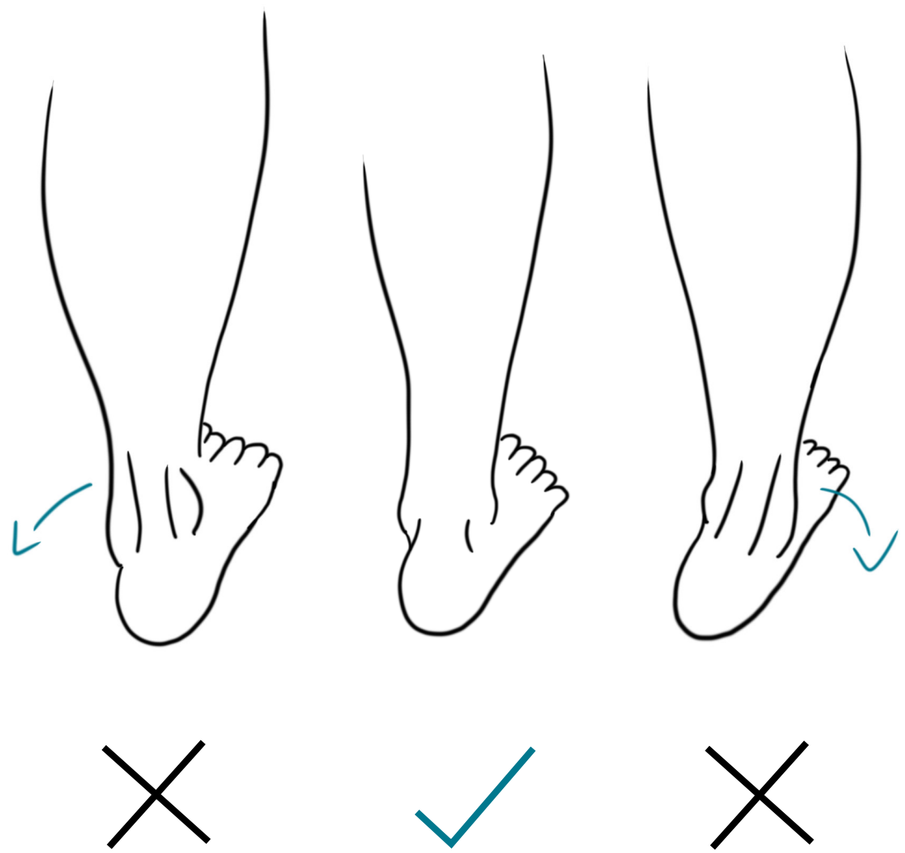
Turning surfaces need reduced friction to help prevent ankle injury.



Stabilization

Studies, such as one published in the British Journal of Sports Medicine in 2016, suggest that stabilizing movement to avoid too much pronation or supination of the foot can decrease injury rates for the ankle.

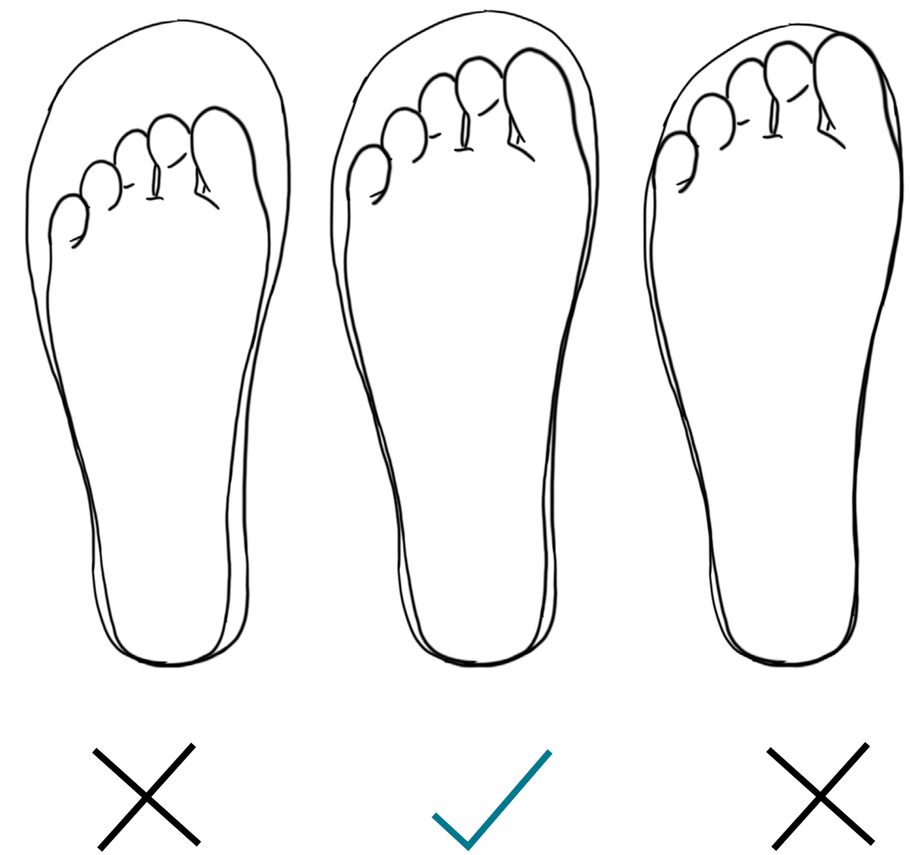
My design should use stabilization to encourage neutral ankle placement.



Fit

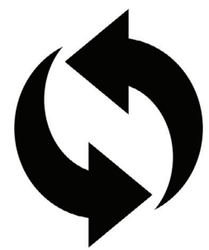
The Journal of Orthopaedic and Sports Physical Therapy found that “inappropriately fitting footwear lead to various foot conditions and abnormal lower kinetic chain biomechanics,” and many medical sources agree.

Adjustable fit could help solve this problem based on individual dancer needs.

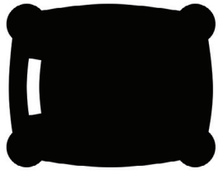


Design Criteria

Proactively approaches injury prevention



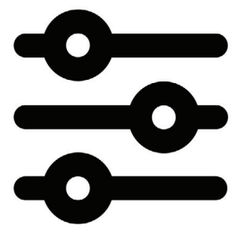
Allows safe turning through reduced friction on turn surface and secure lockdown



Applies modern footwear technology to create cushioning for repeated impact

Minimal design which makes changing between shoes require little adjustment

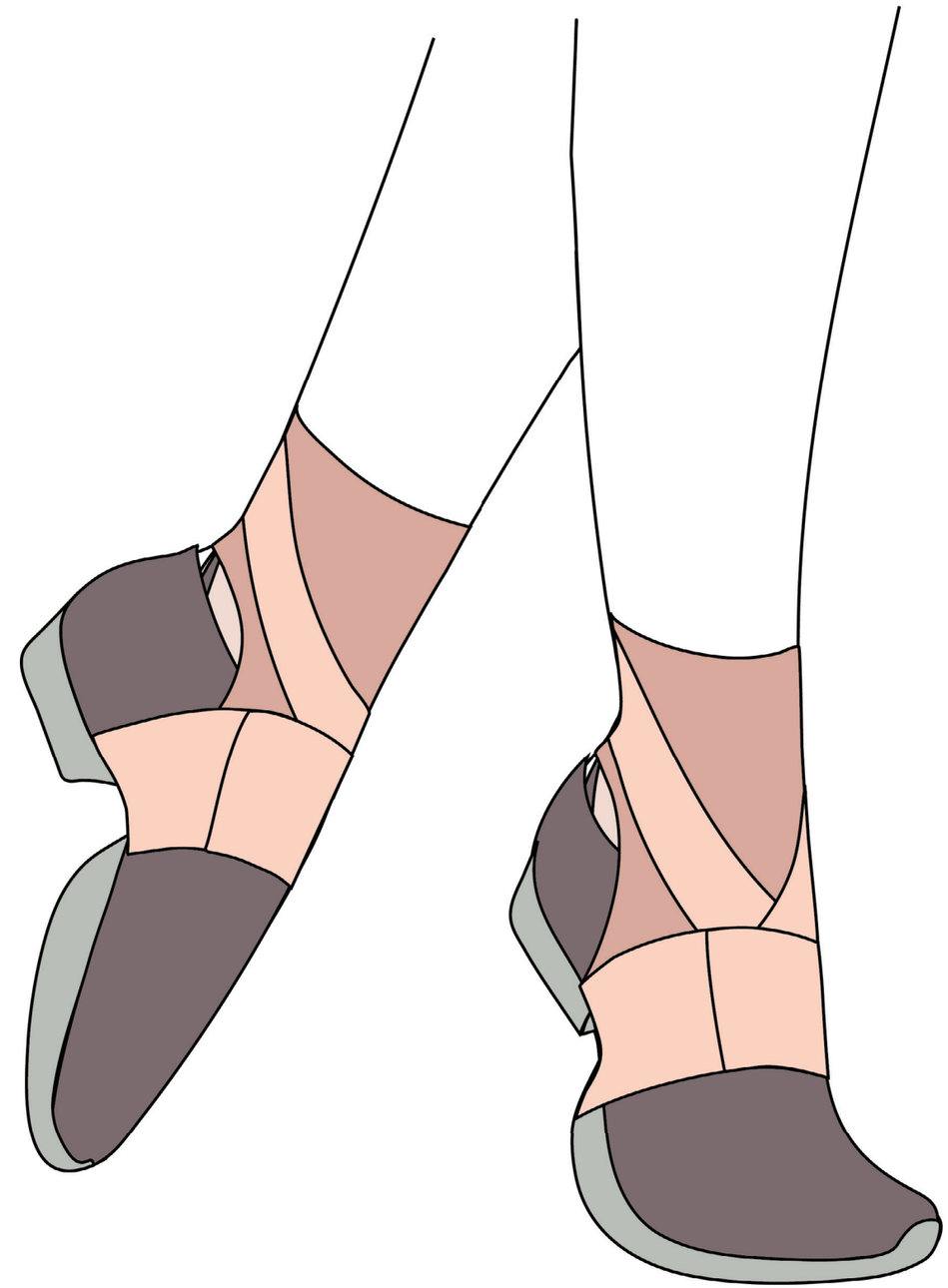
Encourages ankle to remain neutral while still allowing full range of motion

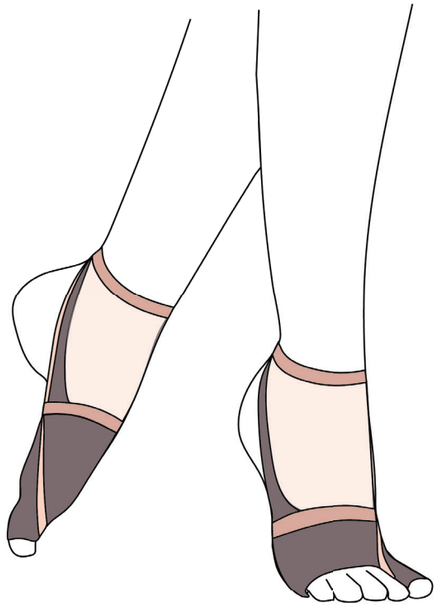


Adjustable to individual dancer needs

Design Development

After completing my research, it was time to translate the information into design concepts. My initial design was named “Pas de Trois,” or dance of three, and focused on addressing the three main opportunities for growth in the dance footwear industry.

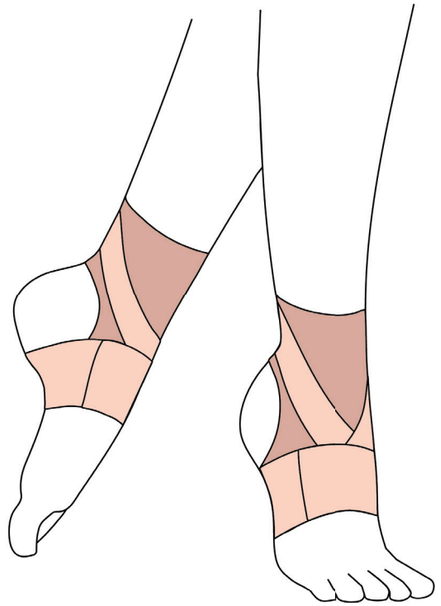




The Barefoot Shoe

The most popular form of dance footwear in the jazz/ lyrical/ contemporary category today is the barefoot shoe. It is a mesh, suede, or canvas construction which is meant to protect the feet from excess friction during activity. It does little else, however, with even less cushion than a standard sock.

While it isn't likely that dancers would completely stop use of barefoot shoes, it is possible to solve some of the pain points. One of the largest issues may be the layering of barefoot shoes with other footwear. In situations such as conventions or even regular training, a dancer will often layer their footwear and clothing to make transitions between styles faster. With a barefoot solution already on the foot, it is unlikely a sock would then be worn if the dancer were to place a jazz shoe or sneaker over the top. However, the common barefoot shoes offer inadequate coverage from blisters and can cause slipping within the shoe itself.



The Ankle Brace

Ankle braces are common in all kinds of physical activity. The level of common use would suggest that the market is already saturated for ankle braces of all kinds. Even with this ubiquity, however, many dancers complain that they are unable to find a bracing solution which functions well for their purposes.

The reality is that dance specific bracing products are few and far between. Even the more simple fabric braces work poorly with many dance shoes. The overlap of the brace and other footwear is often uncomfortable and may force the dancer to choose between a brace and proper footwear. This problem can be solved by creating a more adaptable bracing method which functions in conjunction with dance footwear to provide full support.

The Sneaker

The dance sneakers currently available on the market are dated and unpopular. They lack both modern styling and modern materials. There is a clear opportunity to update dance sneakers even at the most basic level of bringing them to the standards of other modern performance footwear.

In addition, optimizing the design for dance specific activities can easily build the product into something much more marketable. Creating desirable and long lasting products can help combat the impact related injuries that dancers face. Using modern midsole and insole cushioning and innovative textiles, dance sneakers could be used to reach a much broader market while vastly improving the user experience as well. It should also be mentioned that sneakers have become more popular in recent years due to athleisure trends, which only helps build the case for the opportunity that dance sneakers provide.

The Full Collection

The full “Pas de Trois” collection tackles three different important aspects of the current dance shoe market. It updates the current options available for purchase, while tailoring them specifically to dancer needs, and addressing potential injury causes. Most importantly, however, each piece is designed to work together in order to create the most versatile range of footwear options possible. The collection as a whole is customizable to changing dancer needs and creates a cohesive system for tackling common problems.

Moving Forward

The initial designs for Pas de Trois were mostly to get the design on to the page. I focused on incorporating the key elements of the research and feedback I received, with the intent of keeping things minimal. In order to move forward I needed to go back in to the details and deal with each product individually.

For the brace I wanted to explore knitting methods and additional support in key areas. The podiatrists I spoke with were very interested in better bracing systems for dancers.

The sneaker had a lot of areas to be further developed. The initial design was very minimal, just aiming at adding cushioning to the system. However, there were additional support needs to make the shoe functional, and a lot of places that value could be added. The first step would be to add heel and toe counters to increase lockdown.

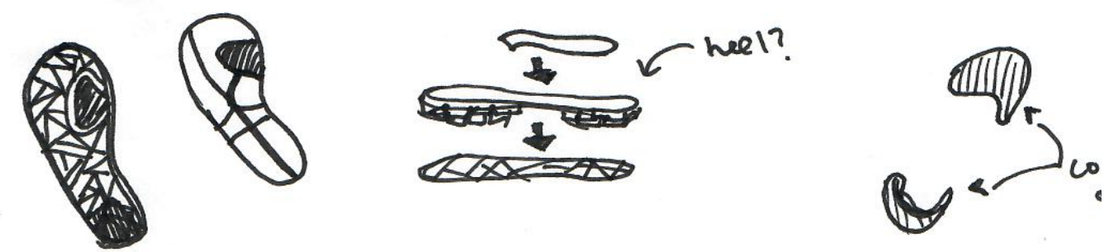
The barefoot shoe was fairly thought out at this phase, but would need added testing to prove the design. I wanted to look into alleviating pain for injuries such as bunions and increasing compression and blood flow.

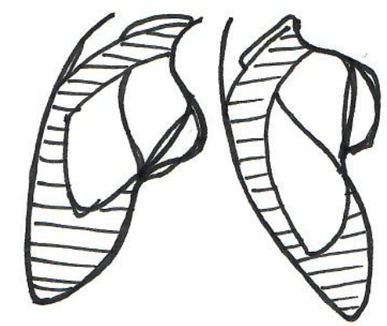
ANKLE COMPRESSION:

- horse shoe pad under ankle bone to prevent fw retention from hollow
- should reach most of foot and several inches
- Lateral & medial support for rollover

CUSHIONING:

- multipart EVA / PU
- gel, air, structure for absorbtion
- carbitex? DFX "tunable stiffness"

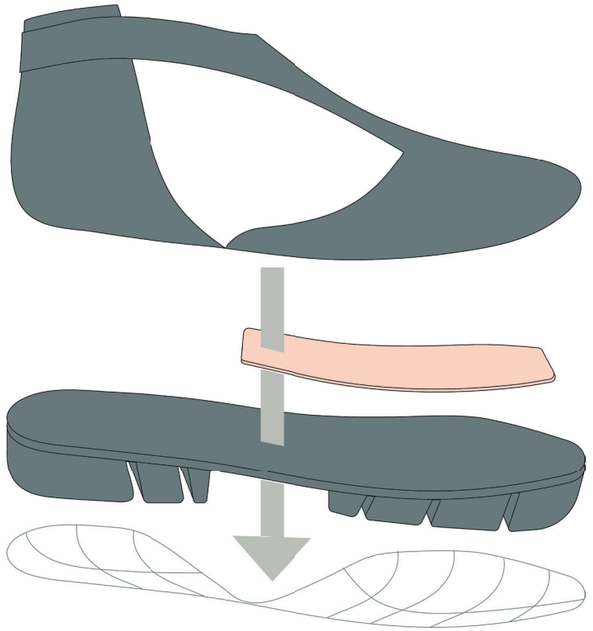




My next step was to really focus in on the sneaker portion of my design. I felt that this was not only the product with the most pieces, but the product with the most opportunity for addressing the issues I had identified.

Second Design Iteration

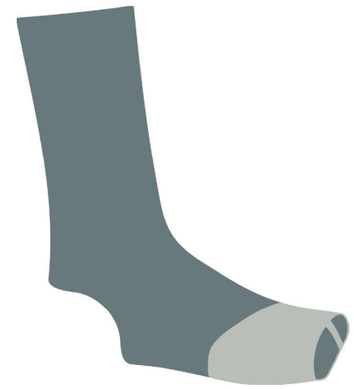
Following my first iteration I evaluated the strengths and weaknesses in the design. Those areas of opportunity were then applied in a new design which aimed to solve the issues of the previous one.



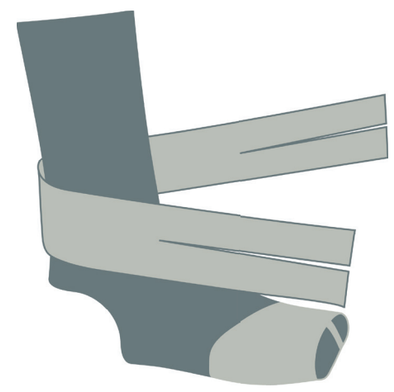
Redesign

My next sneaker design focused on a multi-layer midsole approach. One key design criteria for dance shoes is that they are non-marking. In order to achieve this, the portion touching the ground must be made of an appropriate plastic. These materials, however, may need additional support to have a better feel on the foot. For that reason I structured this design in several layers, with a hard PU cage to give the correct support and an EVA midsole/outsole for the main non-marking structure.

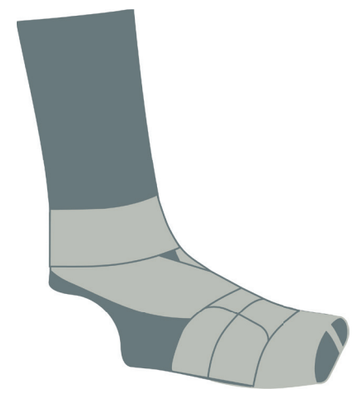
This version also included a Carbitex carbon fiber shank to give the shoe additional spring without restricting movement. The Upper incorporated a heel strap system to easily alter the fit and put pressure on the achilles for stabilization and pain relief. The design was based around having a more full coverage barefoot shoe underneath, and therefore the shoe is fairly open, allowing the knit to show through.



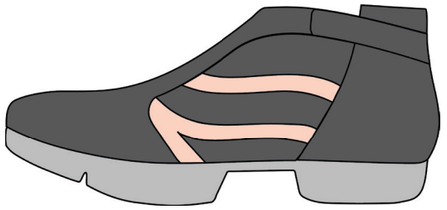
The barefoot shoe evolved into a brace and sock combo. This method allowed for the best compression and coverage.



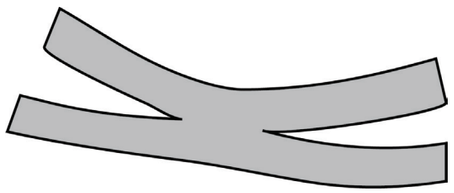
The brace was taken to this x shaped design to add additional support and customizability.



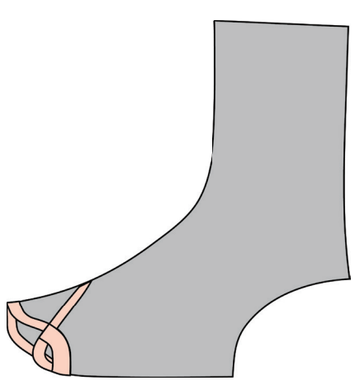
Both parts together make provide complete coverage for the ankle in terms of compression and stabilization of the foot.



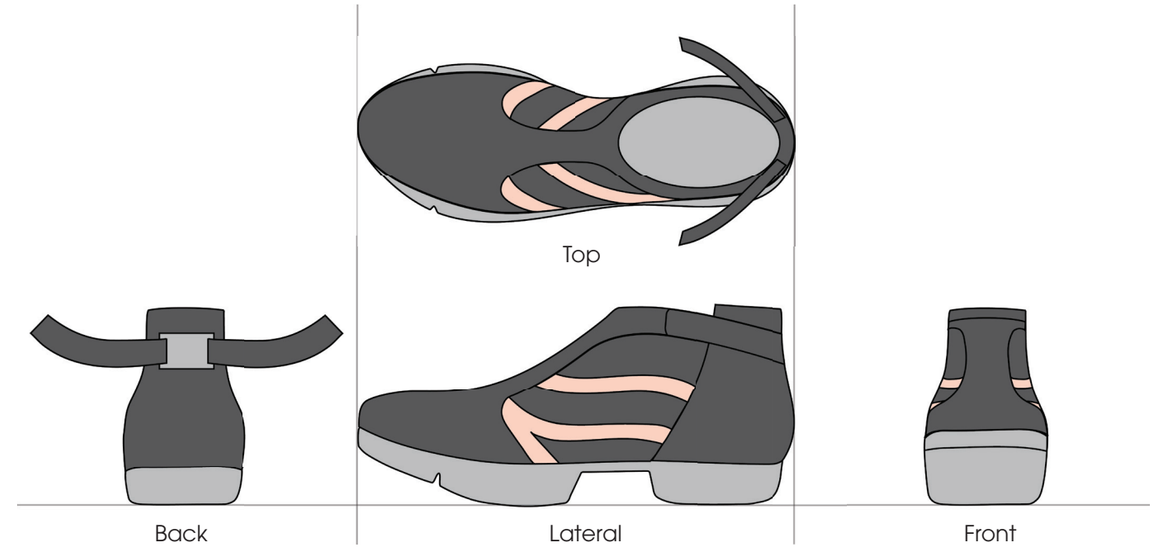
My updated sneaker included more foot coverage with flex panels to allow for an adaptable fit, while still keeping the design close to the skin.



The x shaped brace was optimized dimensionally for functionality both over and under various footwear.



The barefoot compression shoe has an updated gripping band system to ease bunion pain and prevent the product from rotating on the foot.

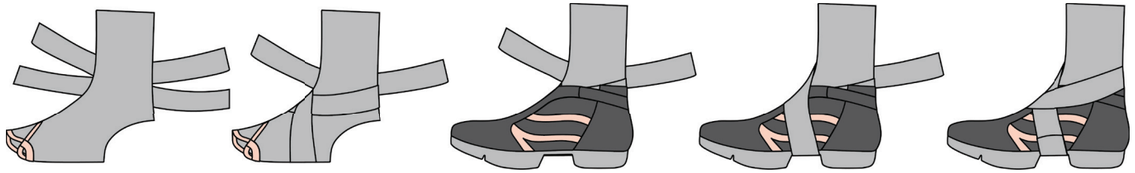


Orthographic Views

The orthographic views for the sneaker helped me to visualize the design in a full 360. It made me think through the interaction of each component and how it could be improved for cohesion.

A few key design elements are highlighted by this overall view of the sneaker. The first is a unique strapping system. The system allows for pressure to be applied to the achilles for pain reduction and stabilization, without interruption of up and down ankle movement. The straps feed through the back piece and then wrap around to the front where they can be attached using flat hook closures. The second feature is the low split soled construction. This allows the foot to be fully articulated and cushioned, hopefully without overly minimizing the feeling of groundedness and closeness to the floor surface.

This illustration demonstrates how two of the three products in my footwear system can be used together. The first layer is the barefoot shoe which provides light coverage and compression. Then the x brace component can be added for additional stability, helping with injury recovery.



This second series starts off with the same first two components. This time, however, only two of the x brace straps are secured initially. The sneaker can then be pulled over the top. The last two x straps are then fully secured. With all three products combined, the user has a full coverage solution that works together for injury prevention and recovery.

Moving Forward

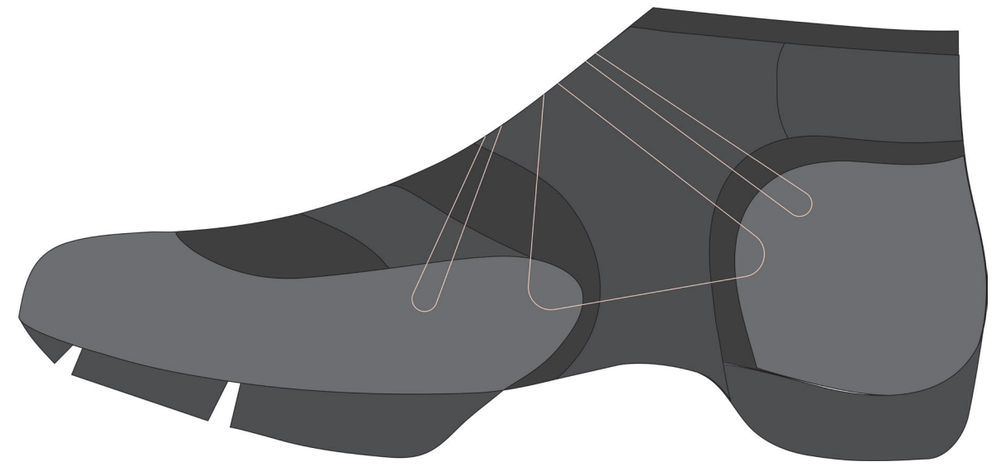
I liked a lot of the solutions carried through this design, but it still lacked a few things.

This design had a lot of seams and overlaps and I was worried about comfort on the foot with this variety of layers. Things would have to be streamlined in order to avoid uncomfortable pressure points.

On top of this, the aesthetics of this design was not where I wanted this to be. It is slightly for sleek than a typical dance sneaker, but the overall impact wasn't as modern as I thought was necessary. Obviously, this was not the first priority for the design, but it was something that would need to applied in order to get the full impact of the product.

Third Design Iteration

The second iteration proved my concept in a lot of ways, but there was still development to be done. Some of the previous key design elements carried through to this next version and a new more elevated aesthetic was applied.

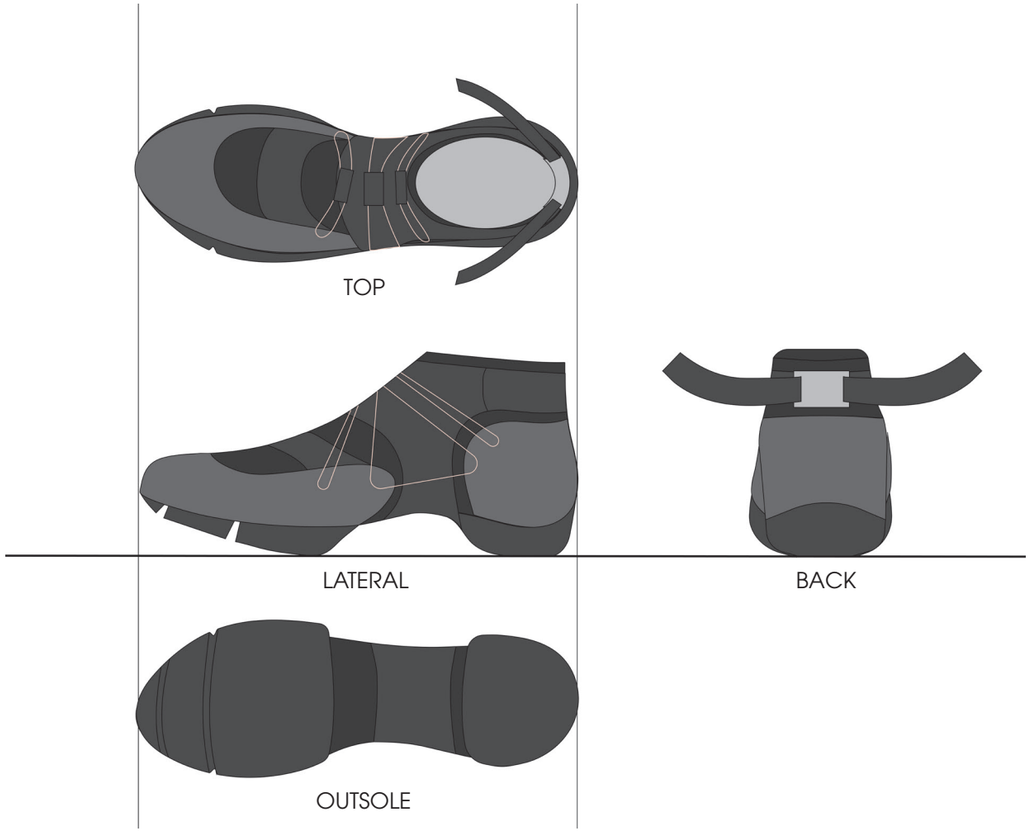


Updating the Sneaker

Focusing back in the sneaker allowed me to address the most pressing issues from the previous iteration. I wanted to incorporate more style into this version while still improving functionality.

The first step was to alter the fit adjustment system. The previous version allowed for some alteration, but only truly in the heel to toe direction. The new system allows movement both heel to toe and side to side. This new design also had the form language of the more recent boa system aesthetic.

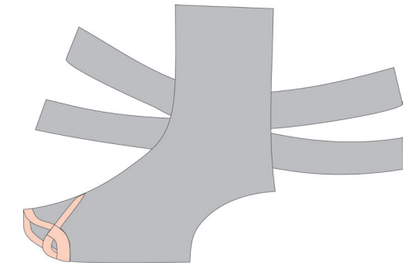
The second step was trying to push the overall design to a more modern and refined style. This version leans more towards professional soccer cleats where the key accent is the silhouette of the foot, giving everything a fast feel and improving athlete range of motion.



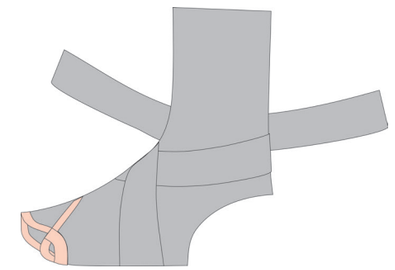
Orthographics

In the orthographic views you can see the design elements in more detail.

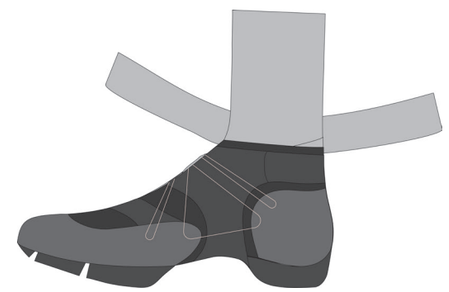
The adjustable heel strap system for supporting the dancer's achilles is still carried through to this design, while also expanded to give extra arch compression support. The low profile midsole is also continued. heel and toe panels were expanded to cover to the end of the ball of the foot and underneath the malleolus to improve lockdown. An additional anti-rotational strap was also added to the toe box for extra support.



The barefoot shoe is shown with the x brace before fully securing the straps.



The first two x straps are secured down against the foot.



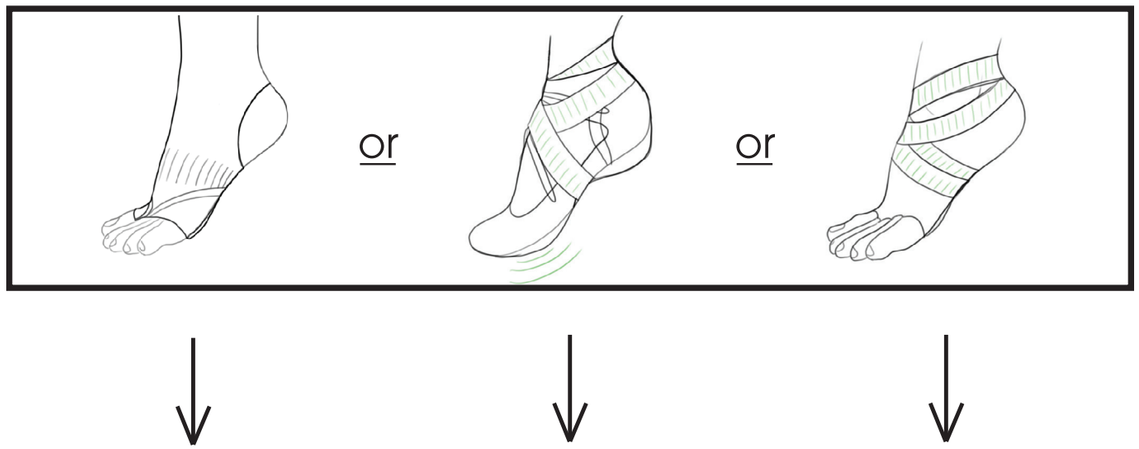
The sneaker is then put on over the top of this combination.

The first strap is secured on one side of the foot over the sneaker.

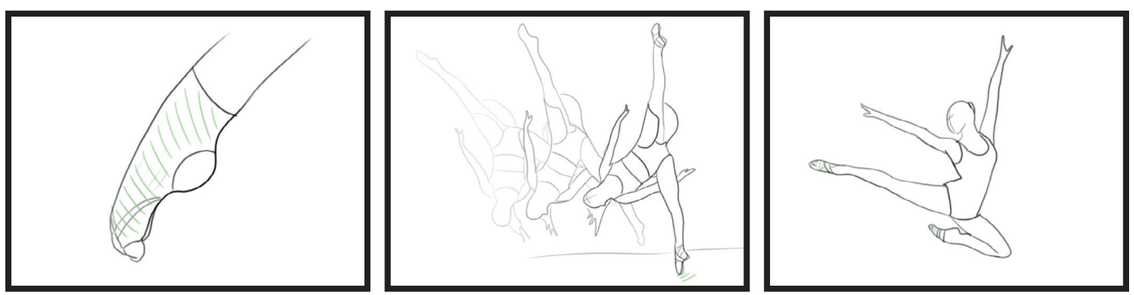
The second strap is secured on the other side of the foot over the sneaker.

On the previous page you can see an early storyboard of how the products would be used.

The first three frames show the current situation. Dancers are training in inadequate footwear, which leaves them vulnerable to injury.
The dancer is seen practising and rolling her ankle when landing a jump.



The next frame shows three options my design provides. The first is just the barefoot shoe. The second is the sneaker with the x brace on top. The third is a conventional dance shoe with the x brace worn on top.



Fast recovery | Impact reduction | Versatility

The final frames show the strength of each product combination. The barefoot shoe alone provides compression, which aides in blood flow and injury recovery. The sneaker and the x brace together provide impact reduction and help keep proper alignment to avoid rolled ankles. The x brace alone provides extra support for the ankle with any shoe, even one that is not from my specially designed system.

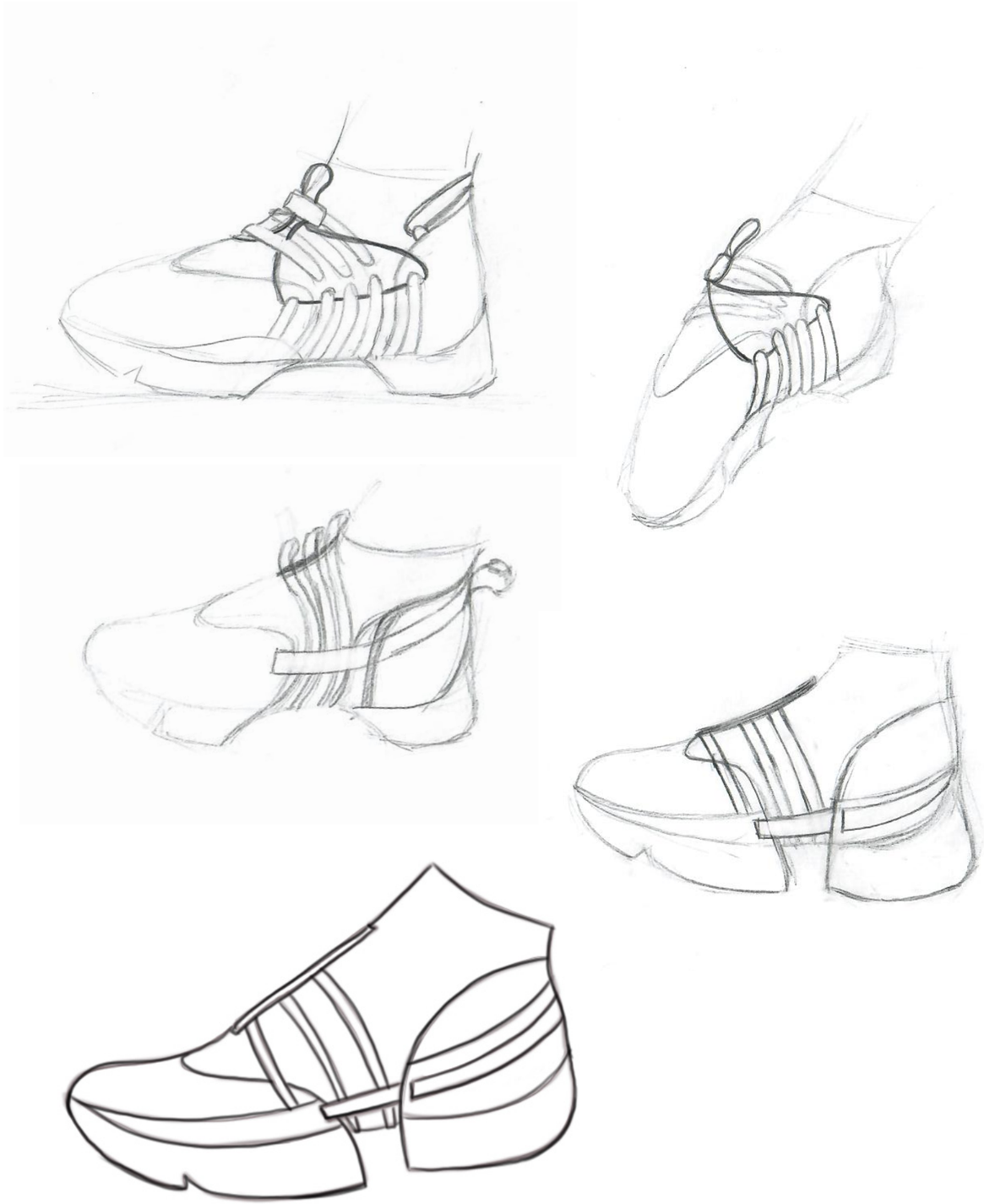
This is an illustration of how my design addresses a wide range of pain points through customizable use.

My first physical prototype allowed me to test out different strap patterns and attempt initial pattern making.

The overall design was pretty successful, but the construction needed improvement. The toe coverage was also too small.

Fourth Design Iteration

I used everything I learned from the first round of prototyping and testing to land on a more final design. There were still details to be developed, but with two more rounds of prototyping my final design took shape.



Second Prototype

With each round of prototyping I asked the dancers of the on campus club Rhythm and Motion Dance Company to give me feedback. You can see this testing pictured to the left.

My second full prototype was a more advanced version of the first design. It featured toggles and nylon shock cord in the tightening system and the heel and toe panels were adjusted.

An important difference in this version is that I debated combining the x brace into the shoe, with a compression strap system attached to the shoe. I found that this solution was not effective though, because it created too much bulk on the foot. The previously designed x brace was much more functional and elegant.

The dancers who tested this cited that the leather panels were too small on this prototype and didn't cup the foot nicely as a result. The toggle system was well received.

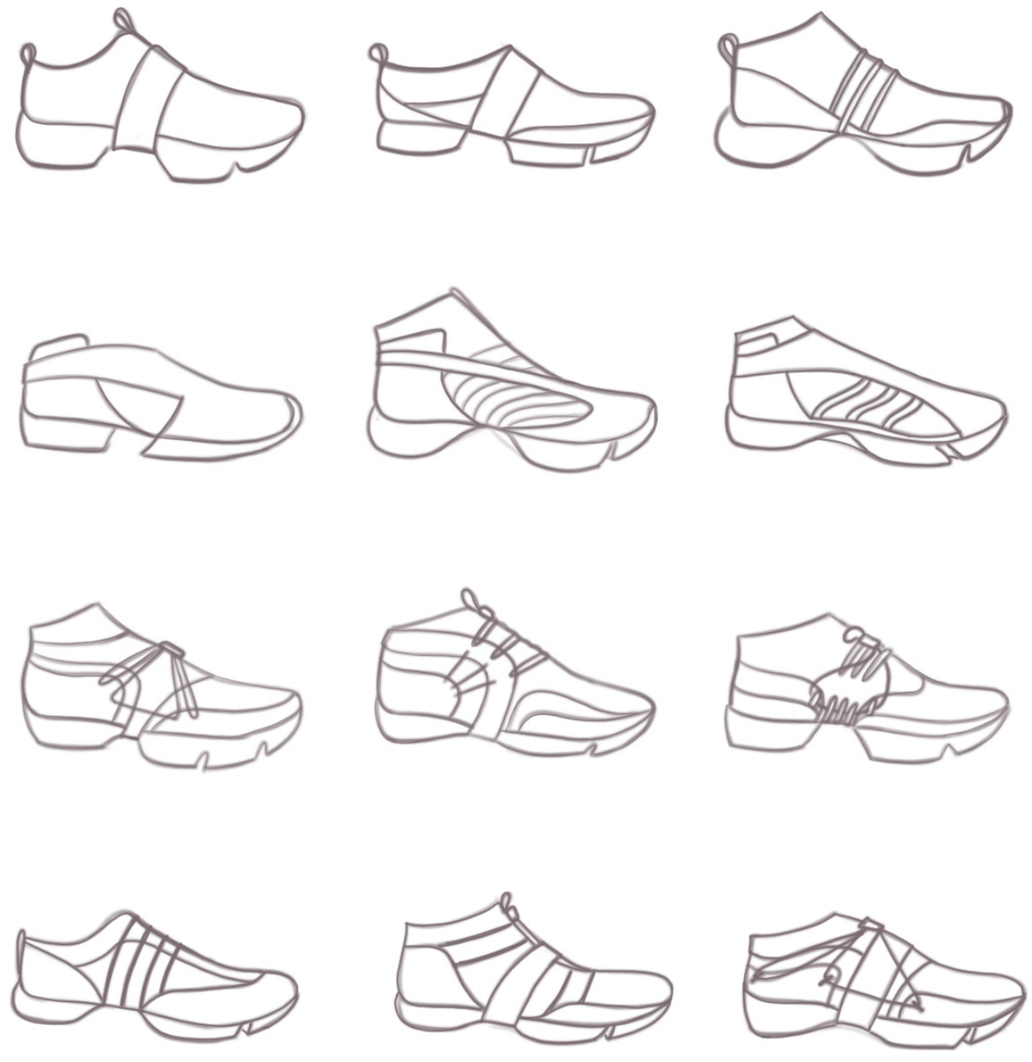
Third Prototype

This final prototype and the testing I carried out would lead me to my final design.

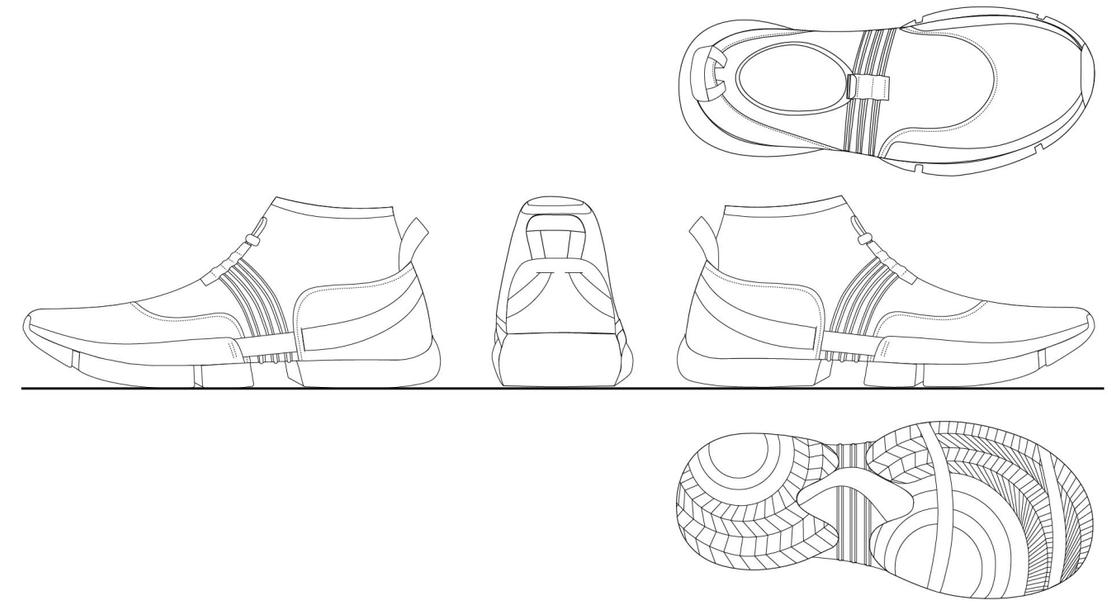
All of the dancers I tested this prototype on all had positive responses to it. They loved the lightness of the shoe and freedom of it. Each of them commented about the “springiness” and cushion of the system. The one common complaint was that the upper of the shoe didn’t rise high enough, causing some uncomfortable friction at the heel.

One of the most beneficial outcomes of this prototype was seeing the adaptability of the fit in use. Dancers from shoe size 6 to 7.5 all fit in the shoe with no complaints of instability or pain caused by the sizing.

This prototype was very close to my final design, it just needed a few more panels for added finesse.



Here you can visualize the evolution of my design as I went through my design process. Some versions were never fully explored, but acted as a mental segway into the next design.



Final Design Orthographics

All of my development culminated in this final 360 degree design.

The sneaker boasts adaptable fit from toe to heel and side to side, a close to skin feel that allows full foot articulation, arch hugging compression, and a customized dance specific outsole grip.

The rise of the upper was extended to add more coverage at the back of the heel. The tightening system around the arch of the foot is encased to keep proper alignment and a low profile. An additional toe panel was also added to anchor the heel strap.

The overall design kept the most important aspects of my previous designs, but repackaged the elements to make the product as efficient and intuitive as possible. Every detail of the shoe was evaluated with care for improvement opportunities.

The final result is a design that is modern, comfortable, adaptable, and visually improved from the products currently on the market.

Design Criteria Revisited

Proactively approaches injury prevention

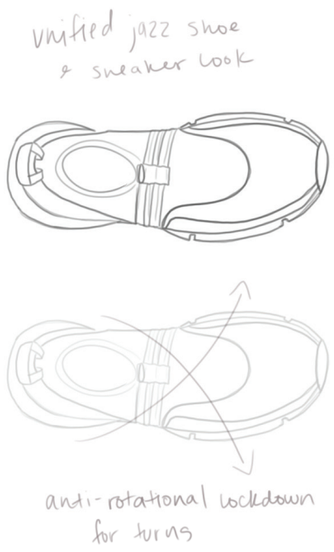
Allows safe turning through reduced friction on turn surface and secure lockdown

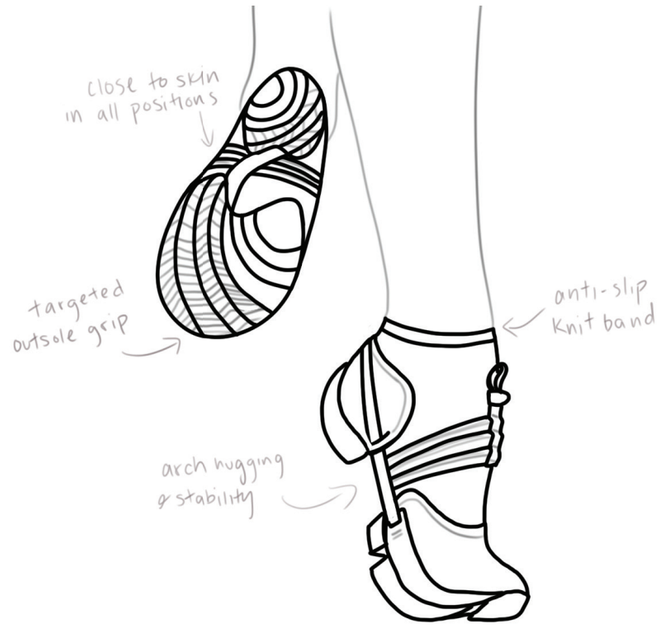
Applies modern footwear technology to create cushioning for repeated impact

Minimal design which makes changing between shoes require little adjustment

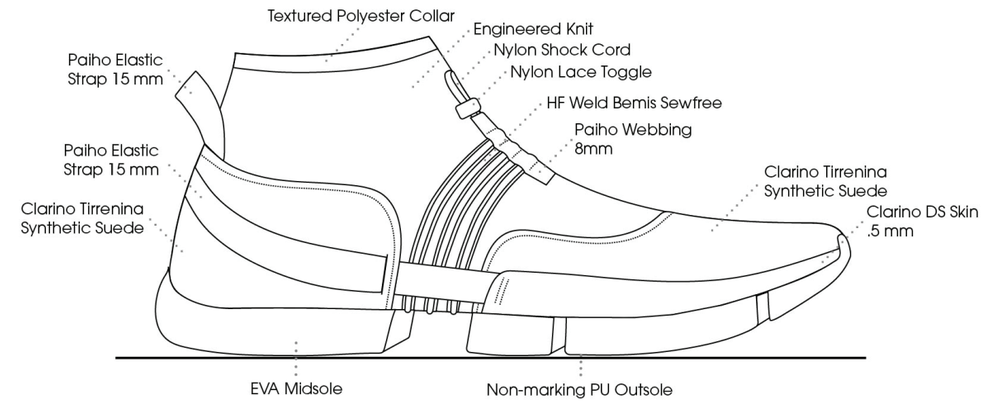
Encourages ankle to remain neutral while still allowing full range of motion

Adjustable to individual dancer needs





Some design considerations for the overall shoe and the specifics of the outsole component are detailed in these process sketches.

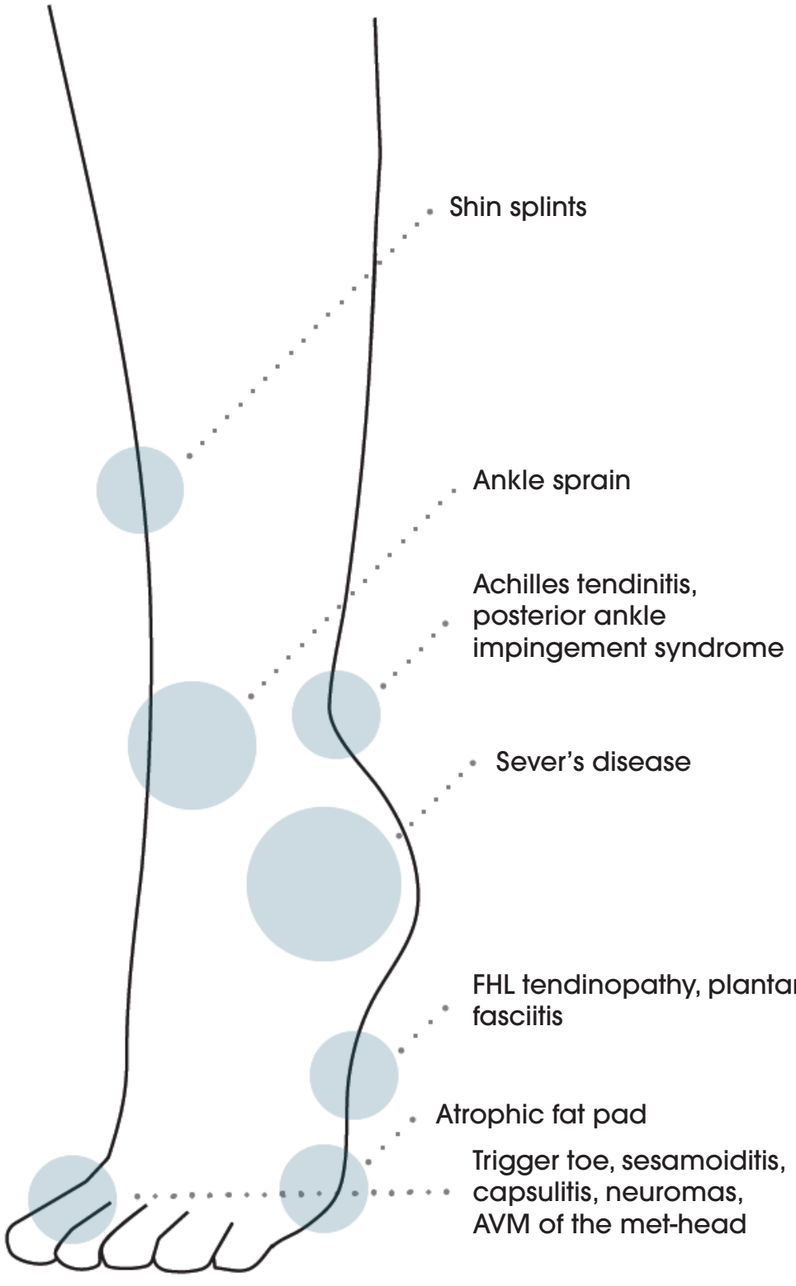


Material Callouts

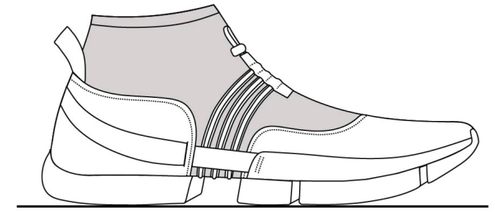
Throughout this project I looked into a variety of materials that I thought may be applicable to my design. For me, the most important factor was that the materials be up to the same standards of other performance footwear. While current dance sneakers on the market still use traditional materials that haven't been updated for more than a century, performance footwear in all other categories have moved to advanced technical materials.

The hero materials in this design are the high frequency welded panels, synthetic fibers, and optimized sneaker cushioning. The HF weld materials are very current in the footwear world, and keep the sneaker lightweight and comfortable. The synthetic fibers give the best durability and versatility, while also enabling HF weld bonding. The outsole and midsole are mostly standard to modern sneakers, but have the special considerations of a split sole construction and non-marking materials.

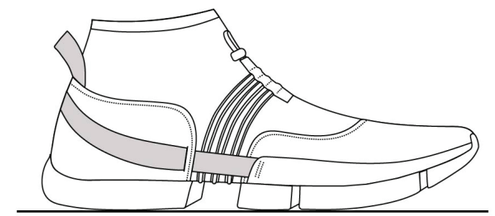
Overall, the material palette of my design is modern and highly technical without losing classic visual cues such as suede texture.



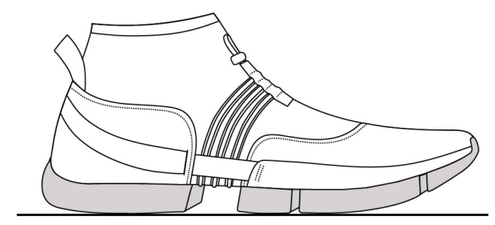
Midsole cushioning helps in reducing many of the injuries I found in my research, but the design also has specific elements which tackle different types of injury.



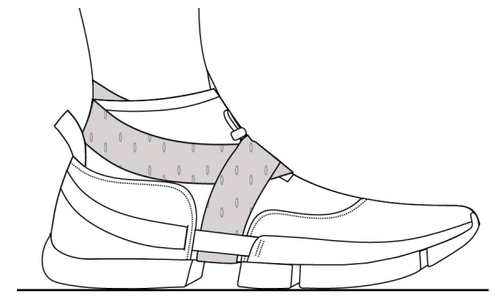
Bloodflow and recovery



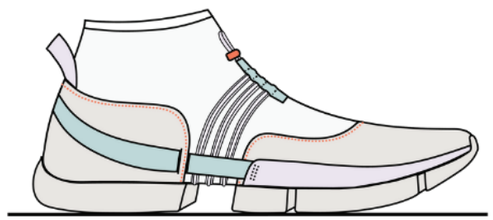
Achilles stabilization and adaptive fit

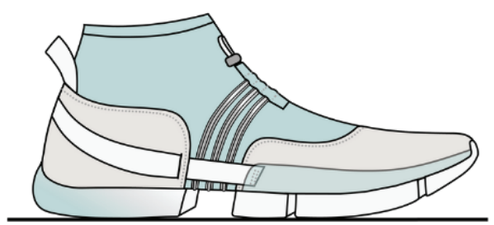


Impact cushioning and overall injury prevention



Ankle stabilization and arch support





I explored a range of colorways to fit into expected dance uniform colors, as well as performance looks. In the end, I found that the teal performance colorway spoke the most to my design.

Thank You!

Casey Davenport
Ballet Instructor

Kristen Stoller
Studio Owner and
Dance Instructor

Bridget Derville-Teer
Professional Dancer

Jefferson RAM Dance
On-Campus Dance
Organization

Anna Smith
Pensole MLab and
CMF Designer

Miss Suzette Henri
Pensole MLab Founder
and CMF Designer

Becky Flax
Textiles Professor

Sabrina Pinello
Textile Design Student

Ali El-Kerdi
Program Director for
MS in Athletic Training
PhD, DPT, PT, ATC,
CAT(C) CSCS, EMT

Jared Remmers
DPM Assistant Director
Podiatric Medicine
and Surgery Residency
Program

Craig Skalla
DPM Podiatry Specialist

Moving Forward

While the design portion of my senior year has come to an end, there is still more work to be done. In the upcoming weeks and months, as the necessary tools become available in the current pandemic situation, I plan on furthering my effort on this project.

I have been developing a 3D model of my custom outsole to conduct testing. After my design has been tested for function and tolerances, I will be purchasing a 3D printed version to utilize in a final model.

One final model will be created with all of the necessary components. The model will be as close as possible to my final design, and include high quality materials and accurate patterning.

After my final model is complete I hope to get some photography of the result. This photography, or potentially video, will serve as the final deliverable for my project.

Thank you for following along with my senior capstone journey!