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**Basketball Footwear, Adaptable Vamp Modular Mid-sole To
Better Match Foot Shape And Player's Needs**

By

Zihan Luo

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in Partial Fulfillment of the Requirements

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Thesis Committee

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Basketball Footwear, Adaptable Vamp Modular Mid-sole To Better Match Foot Shape And Player's Needs

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Abstract:

The left and right feet are not exactly symmetrical, including the form, muscle strength, yet the left and right sneakers on the market are equal. Through the configuration of modular basketball shoe mid sole, users can choose their own basketball shoes that fit both feet. This project is a basketball footwear works those problems mention above.

Introduction

Basketball is a physically demanding sport that places a lot of stress on the use of the feet with actions like jumping and running, quick stops, change of direction, and physical confrontation. This means that athletes that play basketball need shoes that will support the foot and prevent as much stress-related injury as possible. I intend to develop a shoe that will accomplish these feats.

Problem Statement

All the shoes on the market have the same shape of the left and right feet, shoes cannot fit the foot well because human body is not perfectly symmetrical. According to scientific analysis¹, most people's organs are not only asymmetrical in appearance, but also have many subtle differences in function between the left and right parts. Most people have different sizes of the left and right side of the face, and when they speak, the muscles of the face are more powerful and frequent on one side than on the other. Those who mainly move the right muscle group are called "right face", accounting for about

1 "Natural Asymmetry of the Human Body." <http://www.cqvip.com/Main/Detail.aspx?id=31606780>, 2009. <http://www.cqvip.com/Main/Detail.aspx?id=2335556>.

75% of the population; those who mainly move the left muscle group are called "left face", accounting for about 24% of the population, also everyone's foot is unique and so shoes need to be designed to fit each unique foot. The solution given by the merchants is to choose the bigger one to fit the big feet², which seems that you have to sacrifice your smaller one. It might increase injury risk in comprehensive sports.

Project Overview

The footwear's primary functions to achieve size and shape shoes that are differentiated will be split into two parts: the support system and the wrap system. Athletes that do such strenuous physical activity for a long period should have a pair of shoes that will not let the foot collapse or shift in uncomfortable and incorrect positions while playing. The support system must be able to support the foot arch and the Achilles tendon by being placed in the correct part of the shoe. It also needs to be made, at least partially, of hard material like carbon fiber or TPU(Thermoplastic polyurethanes). However, the hard material cannot become too stiff because it will limit the flexibility of the foot work a player can do.

The human body is asymmetrical, including feet, yet the market for shoes only sells in pairs that are of the same length and width of each other. While useful for fashion, this is not useful for function, especially for athletes who need their footwear to match them on a deeper level than the typical, every day person. This is why the wrap system I plan to make will be able to adapt to different feet individually. Usually, the wrap is made of a lace material. I kept the base of shoe lace but expanded upon it to give it more control. This means that I attempted to make the lace tighter by the heel and

2 "Sort." SALOMON. Accessed April 11, 2022. <https://www.salomon.com/en-int>.

the toe box for form fit.

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Wrapping System

The human body is asymmetrical, including feet, yet the market for shoes only sells in pairs that are of the same length and width of each other³. Weighing up the cost and functionality, I believe through my own experience and user interviews that the traditional shoelace system has a good cost performance ratio. Compared to BOA(Company Name) Lacing System⁴ quick lacing system or Velcro, although it takes some time to adjust the laces when using, it can bring a good wrapping feeling to all parts of the foot after lacing up.

3 Myers, Thomas W. Anatomy Trains: Myofascial Meridians for Manual Therapists and Movement Therapists 3rd Edition

4 "Boa® Fit System: Dialed In." BOA® Fit System | Dialed In. Accessed April 12, 2022. <https://www.boafit.com/en-us>.

In order to solve the problem of shoes that do not follow the foot or the length of the left and right feet are different, I used straps and laces connected to the shoe and add a set of straps at the heel to fit the heel. With such a structure to expand the control range of the lacing system, the upper can be well matched to different foot shapes through careful adjustment.

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Figure 1. Wrap System

From the current market, to have a pair of sports shoes that fits your feet perfectly requires the purchase of a custom service, which is a very expensive item and usually only the top professional athletes have individual boots. I designed the modular mid sole so that the average basketball fan can get a degree of customization at a reasonable price.

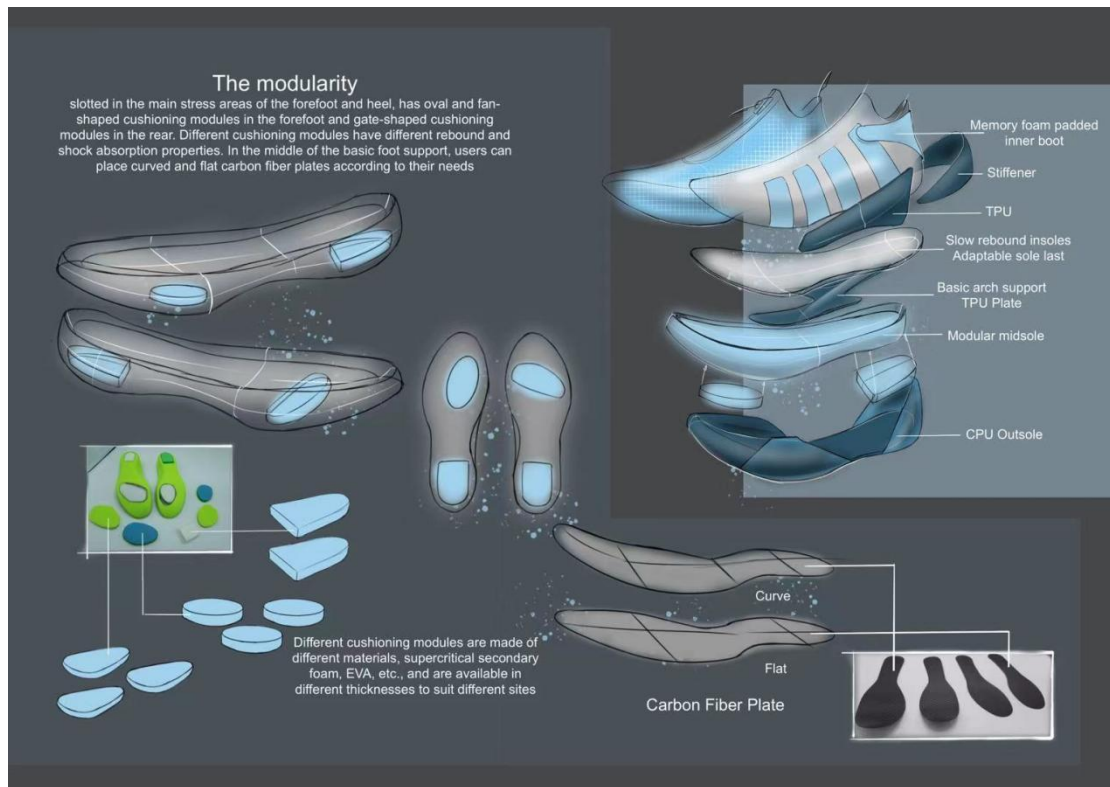


Figure 2. Modular Mid Sole

The first is the choice of cushioning material, two areas of the mid sole of the shoe to make the groove, one is the forefoot power area, the other is the heel force area. I provide different performance midsole materials, EVA(Ethylene-vinyl Acetate Copolymer), Pebax⁵, Poron⁶, etc. At the same time, I made these data into a 3D model to share with users, users can use 3D printers and other ways to create their own mid sole configuration according to their needs, or to adapt to different venues, such as concrete, indoor wooden floors, etc.

The second is the shoe's support system. In order to protect the body and improve athletic performance, basketball shoes will use rigid materials to achieve torsional resistance. From my case

5 “Pebax® Elastomer Family.” Pebax® Elastomer Family. Accessed April 21, 2022.
<https://hpp.arkema.com/en/product-families/pebax-elastomer-family/>.

6 “Poron® Foams: Polyurethane foams: Open-Cell Polyurethane Foams.” Hi, March 3, 2022.
<https://hi-tech-products.com/poron-foam-polyurethane-foam/>.

study, I found that different players have different needs for torsional resistance. A more interesting finding is that even though both power forward and guard use low-top shoes, they have different requirements for torsional resistance structure due to the difference in playing styles, with power forward favoring confrontation and guard favoring change of direction.

For the research stage, I learned from *Anatomy Trains*⁷ and *Sneaks & Feet*⁸ about the body structure of the human body and the corresponding structure of the universe on sneakers. With the development of medicine, the plantar fascia has received a lot of attention. In sports, the plantar fascia plays the role of connecting the fore and aft palm, which is a very important process of force transmission, and a good fascia structure can effectively reduce the loss of force, and athletes can complete their movements efficiently and improve their sports performance. The middle of the sole of a basketball shoe is fitted with a rigid material to ensure that the plantar fascia is not overstretched. The Achilles tendon⁹ is a tendonous structure of the lower end of the muscle belly of the calf triceps, namely the gastrocnemius and the hallux valgus, ending at the heel tuberosity, which is one of the thickest and largest tendons in the body and is important for the body to walk, stand and maintain balance. Achilles tendon rupture is a devastating sports injury. Patients who suffer from Achilles tendon rupture often feel pain in the heel, are unable to bear weight, and have limited plantarflexion

7 Myers, Thomas W. *Anatomy Trains: Myofascial Meridians for Manual Therapists and Movement Professionals*. Amsterdam: Elsevier, 2021.

8 Sneaks & Feet. YouTube. YouTube. Accessed April 12, 2022.
<https://www.youtube.com/watch?v=rOTK2pSNdV4&list=PL8XYDeBGFUCXepvh5syRyRzAGMyeaJMNm&index=4>.

9 "Achilles Tendon Injuries (Tear, Rupture) Causes, Symptoms, Treatments." WebMD. WebMD. Accessed April 12, 2022.
<https://www.webmd.com/fitness-exercise/guide/achilles-tendon-injury>.

and heel lifting movements. At the same time, because the metatarsal tendon, the long toe flexor tendon, the long flexor tendon and the long and short peroneal muscles also have certain functions of plantarflexion of the ankle joint, so after the rupture of the Achilles tendon, the ankle joint can still complete a small range of plantarflexion and heel lifting movements. Therefore, the rupture of the Achilles tendon cannot be ruled out in an emergency because the ankle joint can still be plantarflexed. To protect the Achilles tendon, a stiffener made of TPU(Thermoplastic polyurethanes) is embedded at the heel. At this point, a rigid material from the mid-foot and heel makes up the most basic support system.

For forwards and athletes with better strength, these basic support structures do not completely meet their requirements. I designed two additional carbon plates of different types to complement the basketball shoes. Carbon fibers or carbon fibers (alternatively CF, graphite fiber or graphite fiber) are fibers about 5 to 10 micrometers (0.00020–0.00039 in) in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages: high stiffness, high tensile strength, high strength to weight ratio, high chemical resistance, high-temperature tolerance, and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, motorsports, and other competition sports. However, they are relatively expensive compared to similar fibers, such as glass fiber, basalt fibers, or plastic fibers¹⁰. The carbon plate has good rigidity and elasticity, which makes the carbon plate bend with great force. When the carbon plate is bent, the carbon plate gains great elastic potential energy making the carbon plate return to its original shape. Using the properties of the carbon plate, you can make the basketball shoes in the violent

10 "Carbon Fibers." Wikipedia. Wikimedia Foundation, April 9, 2022.

https://en.wikipedia.org/wiki/Carbon_fibers.

deformation occurred, quickly restore the original form, to help athletes more quickly to the next action.



Figure 3. Different Carbon Fiber Plate

To accommodate the inside and big weight players, I designed the flat carbon plate to match their movement style. The planar carbon plate is balanced for forces in all directions, significantly improving stability at the expense of some flexibility, and allowing the basketball shoe to make stable contact with the ground during intense confrontations. For players who focus on flexibility and light weight, basketball shoes that are too stable are not their first choice. I made an arc in the forefoot, in a straight line movement, the arc carbon plate will produce a geometric rolling phenomenon, this has a similar principle with Nike's racing running shoes¹¹. Players can pick the right carbon board for their situation, or not use a carbon board.

11 Quealy, Kevin, and Josh Katz. "Nike's Fastest Shoes May Give Runners an Even Bigger Advantage than We Thought." The New York Times. The New York Times, December 13, 2019. <https://www.nytimes.com/interactive/2019/12/13/upshot/nike-vaporfly-next-percent-shoe-estimates.html>.

Appearance Design

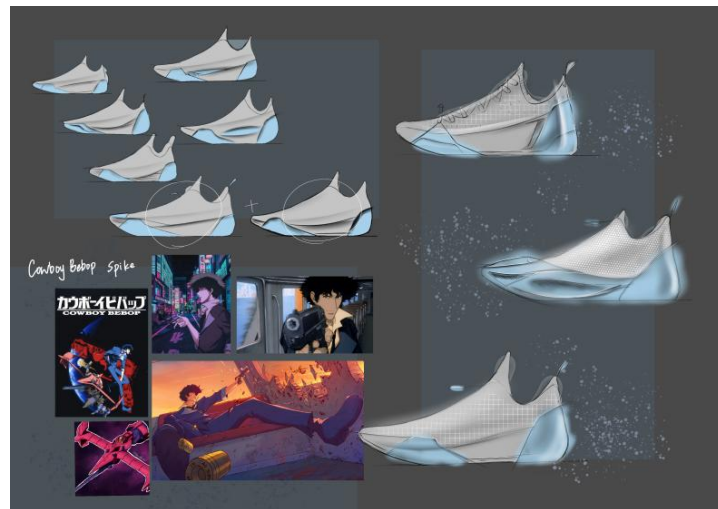


Figure 4. Inspiration

The last is to design the appearance of the sneaker. I was inspired by Spike, the main character in the last century's animated film "Cowboy Bebop"¹². In the story, he is a mysterious man with a mysterious past. I used an opaque elastic mesh material to put the support structure of the basketball shoes, and used a zipper as the on/off design.

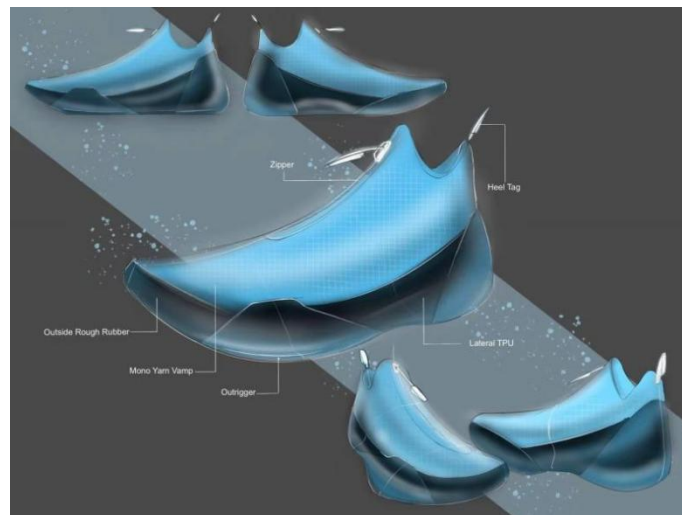


Figure 5. Appearance

12 "Cowboy Bebop." Wikipedia. Wikimedia Foundation, March 27, 2022.
https://en.wikipedia.org/wiki/Cowboy_Bebop.

I chose to use a deep blue colorway to match the simple and technical body of the shoe. The upper is a brighter blue and the sole is a darker blue, while the mid sole material is reflective and refracts different tones of blue under different lighting conditions.

Conclusions

For athletic shoes, how to improve the shoe and foot integration is the shoe design has been solving the problem. The human body is not perfectly symmetrical by nature, and there is a certain conflict between individual differences and the philosophy of the industrial industry. I believe that with the cooperation of multidisciplinary teams, ergonomics, applied physics and medicine, we can design a shoe that better meets the needs of each foot.

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- 4 “Boa® Fit System: Dialed In.” BOA® Fit System | Dialed In. Accessed April 12, 2022. <https://www.boafit.com/en-us>.
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- 7 Myers, Thomas W. *Anatomy Trains: Myofascial Meridians for Manual Therapists and Movement Professionals*. Amsterdam: Elsevier, 2021.
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- 12 “Cowboy Bebop.” Wikipedia. Wikimedia Foundation, March 27, 2022. https://en.wikipedia.org/wiki/Cowboy_Bebop.