

Review Article

The Role of Textile Materials in Sports Footwear: A Comprehensive Review

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Abstract

This article explores the application of textile materials in sports shoes, examining their types, properties, advantages, challenges, and innovations. Textile materials have revolutionized the sports shoe industry, providing improved performance, increased comfort, enhanced style, and eco-friendly options. Different types of textile materials such as natural, synthetic, and blended, are used in different parts of sports shoes such as upper, insole, midsole, and outsole. Innovative technologies such as 3D printing, knitting, weaving, and nanotechnology offer exciting opportunities for creating even more innovative and high-performance sports shoes. However, challenges such as wear and tear, cleaning and maintenance, and pricing must be addressed by manufacturers. Overall, the use of textile materials in sports shoes has transformed the industry, and as technology and sustainability continue to advance, we can expect even more exciting developments in the field of textile materials for sports shoes.

Keywords: Textile materials; Sports shoes; Upper; Insole; Midsole; Outsole; Durability; Sustainability

Introduction

Textile materials have become an integral part of our daily lives. From the clothes we wear to the furnishings in our homes, textile materials play a significant role. The use of textile materials in sports shoes has been on the rise in recent years due to their numerous benefits [1-3]. This article will explore the applications of textile materials in sports shoes, their importance, and their brief history. Textile materials are materials that are made from fibers or yarns that are woven, knitted, or crocheted together [4,5]. These fibers can be natural, such as cotton, wool, or silk, or synthetic, such as polyester, nylon, or spandex. Blended materials, which combine natural and synthetic fibers, are also commonly used in textile materials [6]. The properties of the textile material depend on the fiber used, the weave or knit of the fabric, and any special finishes that may be added to the material. Sports shoes are designed to provide comfort, support, and protection to the feet during physical activity. Textile materials have become increasingly important in the design and production of sports shoes due to their numerous benefits [7,8]. Textile materials provide breathability, which helps to prevent the buildup of heat and moisture inside the shoe. This can help to prevent blisters and other foot injuries. The lightweight nature of textile materials also makes them ideal for use in sports shoes. The flexibility and durability of textile materials ensure that the shoe can withstand the stress and strain of physical activity [9,10].

Figure 1 represents the composition of different materials used in shoes. Textile materials also provide an opportunity for customization and style in sports shoes. The use of different colors and patterns in textile materials allows for the creation of unique and stylish sports shoes. Additionally, the use of sustainable and eco-friendly textile materials has become increasingly important in the production of sports shoes [11]. Many companies are now incorporating recycled materials and natural fibers into their sports shoe designs, which is beneficial for both the environment and consumers. The use of textile materials in sports shoes has a long history. The earliest sports shoes were made from natural materials such as leather and canvas. These materials provided durability and protection but were often heavy and inflexible [12,13]. As technology advanced, new materials were developed that improved the performance and comfort of sports shoes. In the 1960s, the use of synthetic materials such as nylon and polyester became more common in sports shoe production. These materials were lightweight and flexible, providing a better fit and greater comfort for athletes [14]. The development of new weaving and knitting technologies has also had a significant impact on the use of textile materials in sports shoes. In the 1990s, Nike introduced Flywire technology, which used high-strength threads to provide support and stability in sports shoes. The use of 3D printing technology has also allowed for the creation of custom-fit sports shoes that are tailored to the individual athlete's foot shape [16].

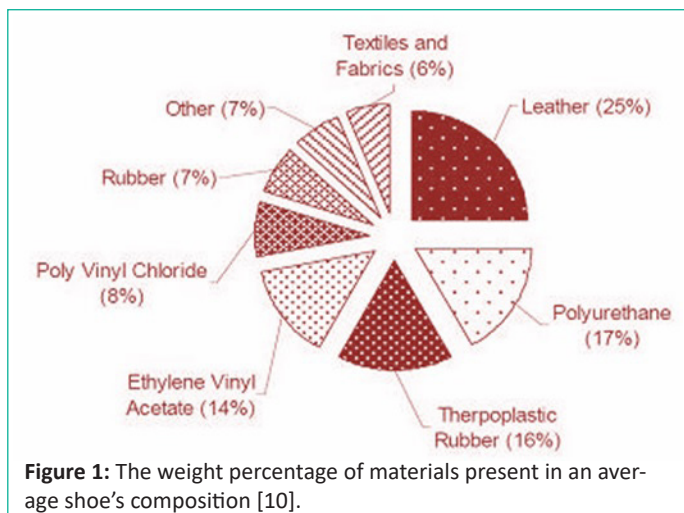


Figure 1: The weight percentage of materials present in an average shoe's composition [10].

In recent years, there has been a growing focus on the use of sustainable and eco-friendly materials in sports shoe production. Many companies are now incorporating recycled materials, natural fibers, and biodegradable materials into their designs. This trend towards sustainability is likely to continue as consumers become more environmentally conscious [17]. In conclusion, textile materials have become an important component in the design and production of sports shoes. The objective of this chapter is to explore the application of textile materials in sports shoes. It will examine the different types of textile materials used in sports shoes, their properties, advantages, challenges, and innovations. By the end of the chapter, readers will have a comprehensive understanding of the benefits and limitations of using textile materials in sports shoes, as well as insights into the future directions of this rapidly evolving field.

Types of Textile Materials Used in Sports Shoes

When it comes to the production of sports shoes, the selection of textile materials is crucial. Different textile materials offer unique properties that can enhance the performance, comfort, and durability of sports shoes [18]. In this article, we will explore the three main categories of textile materials used in sports shoes: natural, synthetic, and blended materials.

Natural Textile Materials

Natural textile materials are derived from natural sources such as plants and animals. These materials have been used for centuries in the production of clothing and footwear [19]. The following are some of the natural textile materials commonly used in sports shoes:

Cotton: Cotton is a soft, breathable, and lightweight material that is commonly used in sports shoes. It is hypoallergenic and can absorb up to 27 times its own weight in water, making it an excellent material for wicking away moisture from the foot [66]. Figure 2 showing the cotton fibre as raw material for shoes.



Figure 2: Cotton as raw material of shoes [21].



Figure 3: EVA foam sole [45].

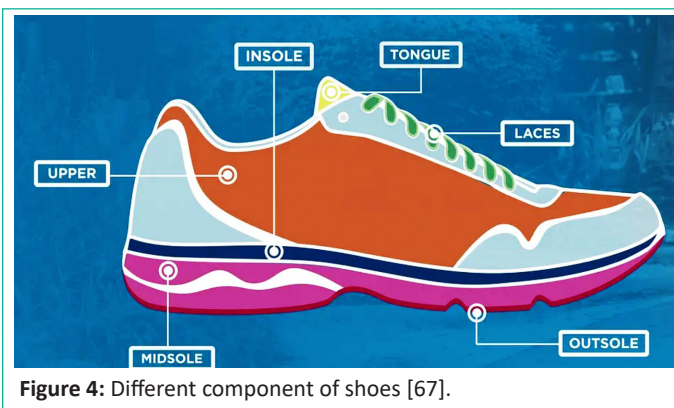


Figure 4: Different component of shoes [67].



Figure 5: 3D printed shoe [70].

Wool: Wool is a natural insulator that is commonly used in sports shoes for its warmth and comfort. It is also naturally moisture-wicking, making it an excellent choice for sports shoes [20].

Silk: Silk is a lightweight, breathable, and moisture-wicking material that is commonly used in the lining of sports shoes. It is also hypoallergenic and provides a smooth and comfortable feel [22].

Synthetic Textile Materials

Synthetic textile materials are man-made fibers that are designed to mimic the properties of natural fibers. These materials are typically more durable and resistant to wear and tear than natural fibers [23]. The following are some of the synthetic textile materials commonly used in sports shoes:

Polyester: Polyester is a lightweight and durable material that is commonly used in sports shoes. It is also moisture-wicking and quick-drying, making it an excellent material for sports shoes [14].

Nylon: Nylon is a strong and durable material that is commonly used in the upper of sports shoes. It is also moisture-wicking and quick-drying, making it an excellent material for sports shoes [14].

Spandex: Spandex is a stretchy and flexible material that is commonly used in the lining of sports shoes. It provides a comfortable and snug fit and allows for ease of movement [24].

Blended Textile Materials

Blended textile materials combine natural and synthetic fibers to create materials with unique properties [25]. The following are some of the blended textile materials commonly used in sports shoes:

Cotton-Polyester Blends: Cotton-polyester blends are a popular choice for sports shoes. These blends provide the comfort and breathability of cotton with the durability and moisture-wicking properties of polyester [26].

Wool-Synthetic Blends: Wool-synthetic blends provide the warmth and comfort of wool with the durability and moisture-wicking properties of synthetic materials. These blends are commonly used in sports shoes for cold weather activities [27].

Cotton-Spandex Blends: Cotton-spandex blends provide the breathability and comfort of cotton with the stretchiness and flexibility of spandex. These blends are commonly used in the lining of sports shoes for a comfortable and snug fit [28].

The selection of textile materials is a critical factor in the design and production of sports shoes. Natural, synthetic, and blended textile materials all offer unique properties that can enhance the performance, comfort, and durability of sports shoes [29]. The choice of textile materials will depend on the specific needs of the athlete and the type of activity they will be participating in. By understanding the properties of different textile materials, sports shoe manufacturers can create products that meet the needs of athletes of all levels.

Properties of Textile Materials in Sports Shoes

The properties of textile materials used in sports shoes are crucial in determining their performance, comfort, and durability. Textile materials used in sports shoes should be breathable, moisture-wicking, durable, flexible, and lightweight to provide the best possible experience to the athlete [26]. In this article, we will explore these properties in more detail.

Breathability

Breathability is the ability of a textile material to allow air to circulate through it, providing ventilation to the foot. Sports shoes with breathable materials can help prevent the accumulation of heat and moisture, which can lead to discomfort, blisters, and foot odor [30]. The following are some textile materials commonly used in sports shoes that have excellent breathability:

Mesh: Mesh is a breathable material commonly used in the upper of sports shoes. It allows air to circulate through it, providing ventilation to the foot [31].

Cotton: Cotton is a breathable material commonly used in the lining of sports shoes. It allows air to circulate through it, providing ventilation to the foot [32].

Wool: Wool is a breathable material that can provide warmth in cold weather while still allowing air to circulate through it [9].

Moisture-Wicking

Moisture-wicking is the ability of a textile material to draw moisture away from the skin and to the surface of the mate-

rial, where it can evaporate. Moisture-wicking materials help keep the foot dry, reducing the risk of blisters, foot odor, and fungal infections [33]. The following are some textile materials commonly used in sports shoes that have excellent moisture-wicking properties:

Polyester: Polyester is a moisture-wicking material commonly used in sports shoes. It draws moisture away from the foot and to the surface of the material, where it can evaporate [34].

Nylon: Nylon is a moisture-wicking material commonly used in the upper of sports shoes. It draws moisture away from the foot and to the surface of the material, where it can evaporate [15].

Wool: Wool is a moisture-wicking material that can absorb up to 30% of its weight in moisture, keeping the foot dry and reducing the risk of blisters [35].

Durability

Durability is the ability of a textile material to withstand wear and tear, maintaining its performance and appearance over time. Sports shoes made with durable materials can withstand the rigors of training and competition, providing long-lasting performance [36]. The following are some textile materials commonly used in sports shoes that have excellent durability:

Synthetic materials: Synthetic materials such as polyester and nylon are commonly used in sports shoes for their durability. They are resistant to wear and tear and can maintain their appearance over time [37].

Leather: Leather is a durable material commonly used in the upper of sports shoes. It is resistant to wear and tear and can maintain its appearance over time [38].

Table 1: Advantages of textile material in terms of functional properties.

Advantage	Description
Improved Performance	- Better Traction: Rubber and polyurethane materials provide better traction on different surfaces.
	- Enhanced Support: Nylon, polyester, and mesh materials offer additional support, reducing foot injuries and fatigue.
	- Flexibility: Mesh and knit fabrics enhance foot movement for increased flexibility during athletic activities.
Increased Comfort	- Cushioning: EVA foam materials absorb shock, reducing stress on the feet and joints.
	- Breathability: Mesh and cotton materials provide airflow, regulating foot temperature and preventing sweating.
	- Flexibility: Flexible and stretchy materials reduce the risk of cramps and discomfort during sports.
Enhanced Style	- Customization: Textile materials allow unique shoe designs that stand out.
	- Fashionable: Trendy and fashionable textile materials appeal to fashion-conscious individuals.
	- Cost-effective: Textile materials can be more cost-effective, making high-quality sports shoes more accessible.
Environmentally Friendly	- Sustainability: Natural textile materials like cotton and wool are renewable and biodegradable.
	- Recycling: Textile materials can be recycled and repurposed, reducing waste.
	- Reduced Pollution: The manufacturing process of textile materials produces less pollution.

Rubber: Rubber is a durable material commonly used in the sole of sports shoes. It is resistant to wear and tear and provides excellent traction on various surfaces [39].

Flexibility

Flexibility is the ability of a textile material to bend and move with the foot, providing comfort and ease of movement. Sports shoes made with flexible materials can help reduce the risk of injuries and improve overall performance [40]. The following are some textile materials commonly used in sports shoes that have excellent flexibility:

Synthetic materials: Synthetic materials such as spandex and polyester are commonly used in the lining of sports shoes for their flexibility. They can bend and move with the foot, providing comfort and ease of movement [41].

Leather: Leather is a flexible material commonly used in the upper of sports shoes. It can bend and move with the foot, providing comfort and ease of movement [42].

Mesh: Mesh is a flexible material commonly used in the upper of sports shoes. It can bend and move with the foot, providing comfort and ease of movement [43].

Lightweight

Lightweight is the property of a textile material to be lightweight in weight, which reduces the overall weight of the sports shoe. Lightweight sports shoes can improve performance by reducing fatigue and increasing agility [44]. The following are some textile materials commonly used in sports shoes that have excellent lightweight properties:

Synthetic materials: Synthetic materials such as polyester and nylon are lightweight materials commonly used in sports shoes. They are lightweight and durable, making them ideal for use in sports shoes [46].

EVA foam: Ethylene-Vinyl Acetate (EVA) foam is a lightweight material commonly used in the sole of sports shoes. It provides cushioning and support while remaining lightweight [47]. The Figure 3 represents the EVA Foam sole.

Mesh: Mesh is a lightweight material commonly used in the upper of sports shoes. It provides ventilation and flexibility while remaining lightweight [48].

The properties of textile materials used in sports shoes play a crucial role in determining the comfort, performance, and durability of the sports shoe. Textile materials with excellent breathability, moisture-wicking, durability, flexibility, and lightweight properties are preferred for use in sports shoes. The choice of textile material depends on the type of sport, the level of activity, and the desired level of comfort and performance.

Advantages of Using Textile Materials in Sports Shoes

The use of textile materials in sports shoes offers numerous advantages. These materials provide breathability, moisture-wicking, flexibility, durability, and lightweight properties that are essential for athletes. Textile materials also enhance the overall comfort and style of sports shoes.

Table 1 provides an overview of the advantages of using textile materials in sports shoes, highlighting the benefits in terms of performance, comfort, style, and environmental friendliness. The following are some advantages of using textile materials in sports shoes explained in details:

Improved Performance

The use of textile materials in sports shoes offers several advantages that can significantly improve performance. For example:

Better Traction: Textile materials such as rubber and polyurethane can provide better traction on different surfaces, improving grip and stability of the shoe. This is especially important for sports that require quick movements or changes of direction, such as basketball, soccer, and tennis [49].

Enhanced Support: Textile materials like nylon, polyester, and mesh can provide additional support, which can help to prevent foot injuries during high-intensity activities like running or jumping. This added support can also help to reduce fatigue and increase endurance [50].

Flexibility: Textile materials like mesh and knit fabrics can enhance foot movement, making it easier to perform different athletic maneuvers. This is especially important for sports like gymnastics or dance, where flexibility is essential [42].

Increased Comfort

Textile materials used in sports shoes can significantly improve comfort levels for athletes. Here are some ways textile materials can enhance comfort:

Cushioning: Textile materials like EVA foam can provide cushioning that helps to absorb shock when the foot strikes the ground, reducing stress on the feet and joints. This can be especially helpful for athletes who participate in high-impact sports like running or jumping [51].

Breathability: Textile materials like mesh and cotton provide breathability that helps to regulate foot temperature and prevent sweating. This can reduce the risk of blisters and odor, making it more comfortable for athletes to wear their shoes for extended periods [52].

Flexibility: Textile materials that are flexible and stretchy can help to reduce the risk of cramps and other discomforts that can occur during athletic activities [53].

Enhanced Style

Textile materials can also enhance the style of sports shoes. Textile materials offer a wide range of colors and textures, which allows manufacturers to create unique and eye-catching designs that appeal to consumers.

Customization: Textile materials provide a blank canvas for designers to create unique shoe designs that stand out from the crowd. This can be especially important for sports shoes worn by professional athletes, who often want to make a statement with their footwear [54].

Fashionable: Textile materials are often seen as trendy and fashionable, making them appealing to fashion-conscious individuals who want to look good both on and off the field [55].

Cost-effective: Textile materials can be more cost-effective than other materials like leather or rubber, allowing manufacturers to produce sports shoes at a lower cost without sacrificing quality. This makes it more accessible for consumers to purchase high-quality sports shoes [56].

Environmentally Friendly

Textile materials used in sports shoes can be more environmentally friendly than other materials. Here are some reasons why:

Sustainability: Natural textile materials like cotton and wool are renewable and biodegradable, making them more sustainable than synthetic materials like plastic or rubber. This can help reduce the carbon footprint of sports shoes [57].

Recycling: Textile materials can be recycled and repurposed, reducing waste and environmental impact. This can help to reduce the amount of waste produced by sports shoe manufacturing [58].

Reduced Pollution: The manufacturing process of textile materials produces less pollution than other materials like leather or synthetic materials. This can help to reduce the overall environmental impact of sports shoe production [59].

The use of textile materials in sports shoes offers several advantages, including improved performance, increased comfort, enhanced style, and environmental friendliness. Manufacturers of sports shoes should consider the benefits of textile materials when designing their products to provide maximum comfort, style, and performance to their customers while reducing their environmental footprint.

Textile Material Applications in Different Parts of Sports Shoes

When it comes to sports shoes, there are several essential components to consider. These include the upper, which covers the top of the foot, the insole, which provides cushioning and support for the sole of the foot, the midsole, which serves as a shock absorber, and the outsole, which is the bottom layer that comes in direct contact with the ground and provides traction. Each of these parts plays a critical role in ensuring optimal performance and comfort during physical activity. The different components of shoes are shown in Figure 4.

Upper

The upper of a sports shoe is the part that covers the top of the foot and includes the toe box, vamp, and tongue. Textile materials are commonly used in the upper of sports shoes for a variety of reasons:

Breathability: Textile materials like mesh or knit fabric provide breathability, allowing air to flow freely in and out of the shoe, which helps to regulate foot temperature and prevent sweating [52].

Flexibility: Textile materials like knit fabrics or synthetic materials provide flexibility, allowing for better foot movement and range of motion during athletic activities [51].

Durability: Textile materials like synthetic materials or leather are durable, helping to protect the foot from injuries or other impacts during sports activities [60].

Comfort: Textile materials like cotton or synthetic materials provide comfort, ensuring that the foot feels comfortable and cushioned during sports activities [20].

Insole

The insole of a sports shoe is the part that rests directly beneath the foot and provides cushioning and support. Textile materials are commonly used in the insole of sports shoes for a variety of reasons:

Cushioning: Textile materials like EVA foam or other cushioning materials provide cushioning to the foot, helping to absorb shock during sports activities and reducing the risk of injury or fatigue [61].

Moisture-wicking: Textile materials like microfiber or other synthetic materials provide moisture-wicking properties, ensuring that the foot stays dry and comfortable during sports activities [62].

Breathability: Textile materials like mesh or other breathable materials provide breathability to the foot, allowing air to flow freely in and out of the shoe and reducing the risk of odor or other foot-related issues [63].

Midsole

The midsole of a sports shoe is the part that rests between the insole and outsole and provides cushioning and support. Textile materials are commonly used in the midsole of sports shoes for a variety of reasons:

Cushioning: Textile materials like EVA foam or other cushioning materials provide cushioning to the foot, helping to absorb shock during sports activities and reducing the risk of injury or fatigue [64].

Durability: Textile materials like rubber or other synthetic materials provide durability, ensuring that the shoe can withstand the wear and tear of sports activities and last longer [65].

Lightweight: Textile materials like foam or other lightweight materials provide a lightweight feel to the shoe, making it easier for athletes to move quickly and comfortably during sports activities [66].

Outsole

The outsole of a sports shoe is the part that comes into direct contact with the ground and provides traction and support. Textile materials are commonly used in the outsole of sports shoes for a variety of reasons:

Traction: Textile materials like rubber or other synthetic materials provide traction, ensuring that the athlete has a firm grip on the ground and can move quickly and confidently during sports activities [68].

Durability: Textile materials like rubber or other synthetic materials provide durability, ensuring that the shoe can withstand the wear and tear of sports activities and last longer [69].

Lightweight: Textile materials like foam or other lightweight materials provide a lightweight feel to the shoe, making it easier for athletes to move quickly and comfortably during sports activities [20].

The textile materials are commonly used in different parts of sports shoes, including the upper, insole, midsole, and outsole, for a variety of reasons such as breathability, flexibility, durability, comfort, traction, and lightweight. The use of textile materials can significantly improve the performance, comfort, and durability of sports shoes, making them more suitable for various sports activities. Sports shoe manufacturers should consider the advantages of textile materials when designing and producing their products, to provide maximum comfort, style, and performance to their customers.

Innovation in Textile Material Technology for Sports Shoes

Innovation in textile material technology has revolutionized the manufacturing process of sports shoes. The advancement in textile technology has not only improved the performance of sports shoes but also enhanced their durability, comfort, and style [18]. In this article, we will explore some of the latest innovations in textile material technology for sports shoes.

3D Printing

3D printing is a technique that involves the creation of three-dimensional objects using digital design files as shown in Figure 4. In the context of sports shoes, 3D printing technology is used to create intricate and complex designs that are otherwise impossible to manufacture with traditional manufacturing methods [71]. The use of 3D printing technology has allowed manufacturers to create lightweight and durable sports shoes that provide excellent performance and comfort.

Knitting

Knitting is another innovation in textile material technology that has transformed the manufacturing process of sports shoes. Knitting machines are used to create a seamless upper for sports shoes, which not only enhances their style but also improves their performance. The use of knitting technology allows manufacturers to create a customized fit for each individual wearer, which results in a more comfortable and better-performing sports shoe [72].

Weaving

Weaving is a traditional manufacturing method that has been used for centuries. However, with the advancement in textile technology, weaving has been transformed into a highly sophisticated and advanced manufacturing process. Weaving technology is used to create a lightweight and breathable upper for sports shoes that provides excellent ventilation and comfort to the wearer [73]. Weaving also allows for intricate and complex designs, which enhances the style and aesthetics of sports shoes.

Nanotechnology

Nanotechnology is a cutting-edge technology that involves the manipulation of materials at the nanoscale level. In the context of sports shoes, nanotechnology is used to create textiles that are highly resistant to water, stains, and other external elements [74]. The use of nanotechnology in sports shoes also results in improved breathability and moisture-wicking properties, which enhance the comfort and performance of sports shoes.

The innovations in textile material technology have revolutionized the manufacturing process of sports shoes. The use of 3D printing, knitting, weaving, and nanotechnology has resulted in sports shoes that are lightweight, durable, comfortable, and stylish [75]. These advancements in textile technology have also contributed to the reduction of waste and environmental impact, making sports shoes more sustainable and environmentally friendly. As the technology continues to evolve, we can expect to see even more innovative and advanced textile material applications in sports shoes.

Challenges of Using Textile Materials in Sports Shoes

Textile materials have become increasingly popular in the manufacturing of sports shoes due to their lightweight, durable, and breathable properties. However, there are some challenges associated with using textile materials in sports shoes that manufacturers need to address in order to provide the best product to consumers [76]. In this article, we will explore some of the challenges of using textile materials in sports shoes.

Wear and Tear

One of the main challenges of using textile materials in

sports shoes is the wear and tear that they undergo during use. Sports shoes are subject to a lot of wear and tear due to the high-impact activities that they are designed for, such as running and jumping [77]. The constant rubbing and bending of the materials can cause them to wear out and lose their structural integrity over time. Manufacturers need to use high-quality and durable textile materials that can withstand the rigors of sports activities.

Cleaning and Maintenance

Another challenge of using textile materials in sports shoes is the cleaning and maintenance required to keep them looking and performing their best. Sports shoes are exposed to a lot of dirt, sweat, and other external elements, which can cause the materials to become dirty and discolored over time [78]. Some textile materials may also require special cleaning and maintenance techniques to prevent damage or shrinkage. Manufacturers need to provide consumers with clear instructions on how to clean and maintain their sports shoes to ensure their longevity and performance.

Price

The price of sports shoes is another challenge associated with using textile materials. Textile materials can be expensive, especially if they are of high quality and durability. The cost of manufacturing and sourcing these materials can drive up the price of sports shoes, which can make them less accessible to consumers with lower budgets [79,80]. Manufacturers need to find a balance between the quality of the materials used and the price of the final product to make sports shoes affordable and accessible to a wider range of consumers.

While textile materials have many advantages in the manufacturing of sports shoes, there are also some challenges that need to be addressed. The wear and tear of the materials, cleaning and maintenance requirements, and the price of the final product are all important factors that manufacturers need to consider when using textile materials in sports shoes [29,81]. By using high-quality and durable textile materials, providing clear cleaning and maintenance instructions, and finding a balance between quality and price, manufacturers can address these challenges and provide consumers with sports shoes that meet their needs and expectations.

Conclusion

In conclusion, the use of textile materials in sports shoes has revolutionized the industry, providing a range of benefits such as improved performance, increased comfort, enhanced style, and environmentally friendly options. Throughout this chapter, we explored the different types of textile materials used in sports shoes, their properties and advantages, applications in different parts of the shoe, and innovative technologies being developed. It is also discussed the challenges associated with using textile materials in sports shoes, such as wear and tear, cleaning and maintenance requirements, and pricing. Manufacturers need to address these challenges by using high-quality and durable textile materials, providing clear cleaning and maintenance instructions, and finding a balance between quality and price. Looking towards the future, there are many exciting directions for textile materials in sports shoes. Advancements in 3D printing, knitting, weaving, and nanotechnology offer exciting opportunities for creating even more innovative and high-performance sports shoes. Additionally, there is a growing focus on sustainability, which means that manufacturers will need to

continue to develop environmentally friendly options for sports shoes. In summary, the use of textile materials in sports shoes has transformed the industry, offering a range of benefits to athletes and consumers alike. As technology and sustainability continue to advance, we can expect to see even more exciting developments in the field of textile materials for sports shoes.

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