Sustainable Approaches for Non-apparel Textile Products Used in Sports

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Abstract Sustainability is the highly demanded practice for continued success in the manufacturing and consumption of different products. In order to reduce the carbon footprint and the energy demands, manufacturers are turning to sustainable approaches in their products. Major brands, already, have turned to sustainable approaches and practices in their manufacturing processes and products either by increasing the life cycle of the product or by reusing the recycled products. Sports textile is one of the major areas of technical textiles where textile materials are used in artificial turfs, sports rackets, balls, shoes, and many more products related to sports and games, besides sportswear. Reused and recycled materials are extensively promoted and used in various sports related products. In this chapter, approaches and methods used to introduce/improve the sustainability of the products are discussed.

Keywords Artificial turf · Sustainability · Shoe · Recycle · Reuse · Carbon footprint

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1 Introduction

Textile materials play an important role in engineering applications. In sports, textile materials are used in different forms with varied functions. Textiles are used as novel substitutes for improving the performance and quality of the material, increasing the life span, and reducing energy and cost. Nowadays, the demand for sports is increasing day by day due to various reasons. Due to the increase in demand and nonavailability, the regular materials and natural turfs are not adequate to meet the demand. A new material with good quality and protection against injury and sustainability is demanded by many players and manufacturers. Various non-apparel textile materials like caps, shoes, football, volleyball, cricket, sleeping bags, sports rackets, helmets, sports net, gloves, turfs, pads, mats, etc. are used in the sport.

In this chapter, how the artificial turf has evolved in different timelines from natural turf to synthetic turf will be discussed. The sustainability of the turf changed by incorporating the new materials in the artificial turf. The properties of different generation artificial turf have been explained in this chapter on sustainability aspect. Injuries and abrasion behavior of artificial turf are elaborated for its sustainability. Materials and properties of other textile materials used in sports like socks and helmets have been explained to enhance the life period and performance of equipment.

2 Natural or Synthetic Turf?

Natural turfs used in lawns, golf courses, and athletic fields require a huge volume of water to maintain the turf. Artificial turfs first came to prominence in 1965, when AstroTurf was installed in the newly built Astrodome in Houston, Texas. Uses of similar surfaces became widespread in the 1970s and were installed in both indoor and outdoor stadiums used for playing baseball and football in the United States and Canada. Artificial or synthetic turf is a synthetic or semisynthetic or combination of natural and synthetic surfaces manufactured with synthetic fibers as a substitute for the natural grass or natural grass together with synthetic grass in a synthetic base [1–7].

Artificial turf is mainly used on sports fields because they can support heavy use and require no irrigation or trimming. Domed, covered, and partially covered stadiums may require artificial turf because of the difficulty of getting grass enough sunlight to stay healthy. Artificial turf has its downside as it has a limited life, has periodic cleaning requirements, uses toxic chemicals from infills, and has some heightened health and safety concerns [8].

Most “real” turf/grass is used in concept of the lawn but also has important role in the agriculture and horticulture settings. It originated in England in the 1600s and by the 1700s was regarded as a “status symbol.” This was due to the extreme care and maintenance it required. This was long before the invention of mowing machines so nicely clipped and cared for lawns where it is much more difficult than today's maintenance. The advantages of natural turfs are dwindling as artificial turfs become more attractive in terms of appearance and maintenance aspects. Natural turf is also a source of food/fodder to many insects and animals. Real turf requires a lot of water to maintain lush green lawns, and that becomes difficult during drought periods. Real turf is also susceptible to many diseases and undesirable grasses growing together. However, real grass has proven, in studies, that it is a safer playing surface for athletes, but with the advancements of artificial turfs, this is becoming statement of the past [9].

There are different types of grasses along with many cultivars adapted to desired areas. The grasses are divided into two subgroups: cool-season grasses which prefer air temperatures ranging between 60 and 75 ºF and warm-season grasses that prefer temperatures ranging between 80 and 95 °F. Cool-season grasses have a high growth rate in the spring that slows down during summer season but gradually rises during the fall [10].

Bluegrass is the most commonly used cool-season grass in the United States and has excellent recuperative and reproductive capacity and develops a dense turfgrass stand with excellent color. Kentucky bluegrass, although it has a slow seed establishment rate, has a shallow root system and requires a high amount of nitrogen and water and necessitates high maintenance, often susceptible to diseases such as summer patch and bill bugs [11]. *Ryegrass* produces a very high-quality turf, has a rapid germination and establishment rate, and can tolerate a very low mowing height but doesn't tolerate cold conditions and is susceptible to fungal diseases such as gray leaf spot [12, 13]. *Fescue* turf is known for its heat, drought, and wear tolerance. It is the most drought hardy cool-season species and is fairly well adapted to shaded areas. Fescues have a coarse texture with poor density and a poor recuperative ability from drought and injury [14].

Artificial or synthetic turfs offer better solution whereever the environmental conditions are not amenable for natural grass growth and places where low maintenance is desired (no mowing, or watering). Artificial turf systems necessitate less maintenance activities in terms of irrigation and trimming [15, 16].

3 History of Artificial Turf

Artificial grass or turf is one of the fields in which the synthetic fibers have been used [17]. Monsanto of the United States first used the artificial grass in 1964, originally called as *Chemgrass* with the high-density knitted nylon product that can support sports activities under the translucent roof structures [18].

Ground covering system, in an artificial turf, includes main turf, marking strip, and boundary strips together with connecting tapes [19–21]. The artificial surface comprises a base woven or knitted or nonwoven fabrics with an open structure to firmly secure upright tufted ribbons and porous structure for drainage of water [2, 5, 7, 21–26]. Fillers of different grades are spread evenly over the pile fabric to cover the surface of the backing fabric and to provide resiliency for absorbing impact shocks from foot traffic and other sports activities on the grass surface [7, 27–30]. From plain synthetic surface to the latest fourth-generation turfs, the synthetic sporting surfaces have undergone a transformation and gained wider acceptance in spite of many criticisms. New generation synthetic sporting surfaces multilayered structure comprising sub-layer, deflection layer, and upper grass layer.

First-generation artificial grass, with high-density and low pile height fibers, was developed in mid-1970s [31, 32] and was used in hockey ground in the 1976 Olympic [32, 33]. These first-generation turfs were made of coarse nylon yarns that often caused wounds and friction under dry conditions. This first-generation artificial turfs opened avenues for new synthetic sporting surfaces though they themselves did not provide a pleasant sporting experience [34] (Fig. 1).

Infills decide the energy absorption, elastic efficiency of the surface, and hence suitability for sports, which in turn safeguards physical integrity of the turfs and safety of sportsmen using the field [28, 35, 36]. The filler allows the outer layer to retain its porosity, and the depth of the infill layer varies depending upon the end use from 50% to 80% length of synthetic ribbons from the backing to the free ends. Various infill layers used in the synthetic turfs are categorized into three groups, namely, first, unfilled layer/water based layers that do not contain any particulate materials but necessitate frequent wetting; second, the sand-dressed layers with filling up to 5–8 mm of the tips of the grass surface with fine sands that remain unseen; and third, the sand filled layers that offer hard and rough field, in comparison with other two types, which in turn reduce the speed of balls [27, 37, 38].

A low-density medium pile height artificial grass, filled with sand in between the fibers to provide the stability, represents the second-generation artificial turfs [39], a kind of pitch that potentially provided control on ball bounce. Such second-generation artificial pitch was first installed in Queens Park rangers of soccer club [40]. Polypropylene based second-generation turf has some applications in soccer, but the first-class soccer lost the priority due to bounce produced in the second-generation artificial turf [41]. The bounce is too high when compared with natural turf, and also the issue of footing of players is also not reliable. The first-generation high-density low pile pitches were suitable for hockey, but the second-generation pitches were not ideal for soccer tournaments [42] (Fig. 2).

Fig. 1 Artificial sports turf – first generation

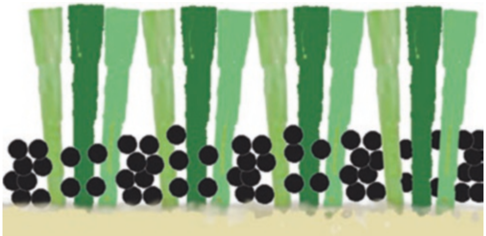

Fig. 2 Artificial sports turf – second generation

In the artificial turfs, good shock absorption properties are obtained with an infill mixture of sand and rubber or a mixture of sand and cork or a mixture of sand, chalk, clay, rubber, and cork, further added with chippings [1, 21, 22, 28–30, 43, 44]. Top course of infills are made up of resilient granules larger (15–30 mesh particles) than at the bottom (about 40–70 mesh particles) [21, 35]. Ground rubber particles of different types and grades like butyl rubber, butadiene-styrene copolymer, butadiene-acrylonitrile copolymer, low-density ethylene-octene copolymer, rubber mixed with carbon black, natural rubber, and vulcanized rubber [26, 28, 45] are used in combination with sand [36]. The amount of polyolefin elastomer content varies between 40% and 50% by weight [29, 43, 46]. Further improvements are achieved using a rubber mat having rubber particles adhered together by urethane, latex, or other binding materials to create a flexible, perforated cushion.

An important advantage of the synthetic turf is that the surface can be rendered more sliding-friendly, i.e., coefficient of friction can be varied using different fibers and their combinations, to reduce the incidents of burning wounds with uniform handle and softness to touch (the low resilience polyethylene yarns with polypropylene yarns). The fibers/fibrillated tapes used for grass surface may be of polypropylene [4, 20, 23, 24, 35, 36, 47–49], polyethylene [36], copolymers of polyolefins [50, 51], Teflon coated polyethylene [52], nylon [53], and melamin-phenol-formaldehyde molding compounds. Synthetic grass blades are made preferably using the combination of textured and non-textured filaments [5, 13], mixture of soft and stiff ribbons [19, 21, 53], monofilaments [36] twined with fibrillated yarns, and the natural grass planted to intermix with the synthetic grass structures [6]. Textured grasslike fibers have a pile height at least 25% less than the pile height of the non-textured pile [36]. Textured grasslike fibers are tufted into the primary and secondary backings with a tuft bind to the primary and secondary backing.

Ribbon structures [19, 21, 28, 29] comprise an alternating mixtures of stiffer ribbons and softer ribbons to provide a natural surface texture, where the stiffer ribbons have a linear density up to 11,000 D and a thickness of 100 μ, while the softer ribbons are of at least 5600 D to 10,000 D with a thickness of about 80 μ [5, 19, 23, 36]. Individual monofilament yarns and/or mono-tape yarns cut from the films are used together to achieve a natural look of grass with varying thickness [36, 47]. The fibrillated yarns are twined around the individual monofilaments so that the composite yarn has an outer surface formed by the fibrillated yarn, with a linear density of 2000 dtex to 20,000 dtex and a thickness ranging from 60 μ to 100 μ. At least 40% of the composite yarn is formed by individual filament yarns, while fibrillated yarn forms minimum 30%.

Synthetic ribbons are made from the slit tapes, and upper portions of the ribbons are longitudinally split into free strands, while lower portions are laterally linked to a lattice structure [19, 21, 24–26]. Strips of ribbons are attached by strips of bonding material applied to the back of the mat, and a particulate material is laid on a matrix of the synthetic grass at least two-thirds the length of the ribbons [19, 25, 46]. Ribbons/fibers have a length about twice as long as the spacing between the rows [Prevost, 2004] that extends between 0.25″ and 1″ above the particulate layer, with the total length of at least 4.5″. Grasslike coverings are made from thermoplastic materials that can be welded onto mesh like thermoplastic substrate [29, 30, 35, 44, 54], with an areal density of 30 g/m^2 to 150 g/m^2.

Longer ribbons or grass structures allow a thicker layer of particulate materials that can eliminate the need for a resilient pad and make installation of the surface simpler and cheaper. Improved synthetic grass surfaces are provided by widely spaced rows of ribbons measured from center to center, of between 8 and 50 mm, in the more closely spaced rows. Wider ribbon row spacing can also cause balls to roll more like they roll on grass, thus improving playing qualities, and this extends the life of the surface with respect to resiliency, wear, and abrasion of the ribbons and improves the drainage. Wider ribbon row spacing facilitates the seaming process, making it easier to loosen the particulate materials for replacement. Wider row spacing of grass in combination with longer ribbons allows better cleat penetration and easy release and improves the playing qualities and reduces risk of injury also.

Third-generation carpets were based on the longer pile fibers of 35 mm to 65 mm filled with both the sand and rubber granules [55]. These third-generation carpets were first introduced in late 1990 in Europe. These carpets are based on softer polyethylene fibers to take a normal stud on surface for soccer and rugby. These third-generation turfs provide added safety to the players due to the usage of softer rubber polyethylene infills [56]. These pitches are preferred for sports where a player falls or slides into the ground, as safety measures [38] (Fig. 3).

4 Fourth-Generation Turfs

The latest developments in these types of turf are coming under the fourth-generation synthetic turfs. Modifications in the existing turfs include use of monofilament fibers, and fibers with textures at variable length without the sand infill are used for rugby and soccer sports [57]. Examples of this fourth-generation soccer, hockey, and tennis facilities are now available in Victoria, and the first prototype of long-pile pitches for football/cricket turf under the Australian rule are also being installed [58, 59].

Fig. 3 Artificial sports turf – third generation

The artificial grounds filled with infill and without infill are majorly used in hockey. The sand infill is used in longer and less dense pile surfaces [49]. The grounds are normally watered before the start of game for unfilled pile surfaces [42]. The third-generation low level synthetic turf used for soccer with rubber or sand infill on a longer pile surface sometimes is sufficient to play the hockey. High-level hockey players prefer to play on unfilled watered pitches to minimize the burn and scrapes. Moreover, the hockey ball rolls and bounces faster in unfilled pitches than the filled one [60]. A study was carried out on three different hockey grounds to analyze the temperature rise in both dry and wet conditions. The increase in temperature on a sand and rubber infill grounds in dry conditions is Less and it is high on a synthetic ground. However, the abrasion was high on a sand infill grounds. The temperature rise is less on wet grounds and also the abrasion [61].

Sand-dressed instead of a sand filled grasses used in second generation are a variation which reduces the sand content approximately 50% to 80% to the regular sand filled pitches for hockey ground [47]. Such turfs move the ball faster due to reduced sand fill, and this reduces the abrasion and wounds when a player falls into the pitches [62]. The use of polyethylene fibers in the artificial grass is installed in international hockey grounds and tested for global level competitions [63].

An 80-mm-long pile turf infills up to 60 mm to absorb the thrown objects like shot put, hammer, javelin, and discus in the athletic grounds without damaging the thrown objects [64]. An artificial reddish sand is used in tennis court turfs due to the development of synthetic clay and reddish sand in artificial grass to minimize the compaction [65].

With more than 5500 synthetic turf fields currently in use throughout the United States, millions of students have the opportunity to practice and play on a sports field that can always be counted upon. Simultaneously, thousands of homes, businesses, golf courses, municipalities, and public spaces have turned to synthetic grass to provide a lush, attractive landscape solution that requires minimal resources and maintenance while saving millions of gallons of water each year. Consider the following benefits [66].

5 Injuries and Artificial Turf

Injuries are part of sports that need to be minimized to have a long term physical and mental health [67–70]. The previous generation turfs are connected with increased chances of injuries in abrasion and lower limb ligament. Introduction of softer polyolefin fibers drastically reduces the skin and abrasive type of injuries compared to the natural turfs. Still, some studies related to skin related injuries in artificial and natural turf reported that the natural turf is more prone to injuries than the third-generation artificial turfs [71–75].

Sliding is an essential element in sports grounds like hockey, cricket, rugby, and other sports. The player has to dive and slide over the turf for certain period of time for reaching the ball when it is moving from the player at fast [76]. When sliding over the synthetic turf, heat is developed and causes injuries like burning and scraping [77].

6 Disposal of Artificial Turfs

Global usage of artificial turf is increasing around 20–25% every year; however, life span of artificial turf is limited, and it is expected to provide good support for a period of around 5–10 years [8, 78].

The waste artificial turf consists of polyethylene fibers as artificial grass fibers, polyethylene or polypropylene carpet backing, and polyacrylate cross-linking agent and fillers as adhesives. The fibers polyethylene, polypropylene, and polyester used in artificial turf are not possible to process thermally since the melting points and viscosities are different for these fibers. Moreover, the adhesives used in the turf are also insoluble and infusible. Besides, the artificial turf consists of crumb rubbers and sands as infill to provide the cushion to the turf [78, 79]. Incineration, landfill, and recycling are used to dispose the waste artificial turfs. Among these methods, the landfill needs large land space and it contaminates the water resources [80, 81], while incineration releases a number of toxic gases.

First step in recycling of waste artificial turfs is separating the parts. Cheng pointed out the waste artificial turf can be shredded, opened, and converted into a usable material for extrusion, or these can be again used in artificial turf manufacturing [8].

Solid state shear milling and inlaid pan milling methods are used to pulverize the polymeric materials into powders [79, 82–84]. The recycled waste artificial turfs are made into ultrafine powder and extruded to wood plastic materials to replace the polyethylene products [79].

7 Socks

Sock is an item of clothing worn on the foot that can reach the ankle and calf to provide warmth and also help to avoid blisters and extend the life of shoes. Most athletics includes socks as a standard component. Basketball, soccer, and cricket are among the sports that demand socks as part of the uniform [85]. Socks are among the most crucial parts of apparel, despite its apparent secondary status. Socks are a sort of knitted clothing that completely or partially encloses the foot and leg. Socks come in a variety of styles and are used for everyday athletic and medical purposes. There are many different colors, sizes, and materials for socks. Some of the key properties and functions expected from socks are listed in Table 1 [86, 87].

Key performance and quality component in socks are the raw material, decided based on health conditions and allergic issues. Since, for instance, some fibers are helpful for diabetic patients while others may create allergy issues, some fibers are helpful for a limited amount of time before causing health issues. Also, the customer is made comfortable by the overall appearance of the socks. Socks made of acrylic or synthetic materials are probably suitable for athletes or those who are very active [88, 89]. Following are some various fabric kinds to look for in sports socks:

Natural fibers such as cotton and wool are mostly used. While cotton by itself is inadequate for a sports sock, it becomes significantly more robust and adaptable when combined with additional materials. Wool is regarded as one of the best and most expensive materials for socks, because it is soft, non-itchy, breathable, and odor-resistant. For winter sports like hiking, skiing, or snowboarding, merino wool is a popular choice because it is recognized for retaining heat when wet. Synthetic fibers like nylon and acrylic are used together to create a cushioned, sturdy sock. Nylon gives it durability, while acrylic contributes to comfort and support. Both fibers aid in wicking away moisture [90].

8 Characteristics of Socks

The greatest socks available today are a blend of several fibers and textiles that increase durability, avoid odors, and keep your feet dry. The qualities required depend on the seasons and the kind of activities engaged by a person [91].

Table 1 Functions and properties of socks [86]

Function	Property expected
Warmthness	Protection to legs, toe, and muscles
Wicking	Wicking the sweat during vigorous running activities
Flexibility	Enhanced stretch
Flexural rigidity	Better durability

- Support and cushioning to shield from blisters.
- Temperature to provide or ensure warmthness and keep skin dry.
- Compression to promote circulation, enhance blood flow, and provide more oxygen to the muscles.
- Slippage and bunching to snug in the right places.

9 Sports Socks

Socks are designed to go with physical activities, and also there are specific shoes developed for walking, running, and climbing used with appropriate socks. Jogging and running are the common movements in high-intensity exercise and sports that cause higher strain on feet. By absorbing moisture and cushioning the feet, socks help to maintain the general health of your feet while increasing blood flow and reduce muscle pain. Improper socks often result in swelling or athlete's foot and excessive perspiration leading foot fungi. Cotton socks absorb moisture, become saturated, and dry slowly, which potentially lead to blisters, hot patches, and chafing. Fibers or combination of fibers and the type of yarns that the socks are composed of have a direct impact on breathability, comfort, and durability.

Football players' socks are one of the important elements in the sports and are not simple regular socks because they ensure optimum fit and protection while playing. Football players use cushioned socks, made to provide a secure grip, protection, and comfort. Football socks are constructed from materials (fibers and yarns) that make the players comfortable to wear and provide a snug fit for sporting performance. Football socks could be either *over-the-calf style or crew design*. Over-the-calf pattern is the significant sock style that offers superior protection for individuals besides keeping athletes warm. Comparatively, *crew design* kind of socks provides better coverage than ankle socks and is suitable for hot weather as it allows the players' skin to breathe. Additionally, it enables the player to drain perspiration rather than fabric naturally. Key features expected from the football socks are that (i) it should be sweat-wicking, (ii) it should provide a grip on the knee and fit properly over-the-calf for adequate protection, and (iii) it should be comfortable for the wearer [92].

Different manufacturers use various combinations of materials to manufacture football socks. One of the socks available in the market has 3% spandex as a necessary component. It comes in several color combinations and has a crew length that will reach mid-calf. Polyester socks are ideal for a variety of sports, including basketball, lacrosse, soccer, and many more. Polyester together with elastane provides a compression fit. In the case of polyester/cotton blends, sock's breathable poly-cotton construction provides the wearers optimum warmth and comfort, while nylon/polyester with elastane is often used in tube pattern for perfect fit. Cotton/nylon with spandex is also used to produce socks suitable for warmthness, with air permeability, and that maintain dry skin [93].

In the case of tennis, characteristic requirements of socks includes (i) light and strong, (ii) contoured fit while moving about the court and (iii) substantial heel pocket, additional cushioning, and/or arch support. Natural mohair or antimicrobial characteristics of merino wool and ultrafine, high-tech performance yarns act as a barrier between the skin and the shoe when combined. Right placement of ventilation panels results in a clean, dry conditions. Socks are also finished with antimicrobial finish for odor-free conditions [94].

Breathability is a crucial factor for socks meant for volleyball players, similar to other sporting activities, since volleyball is a physical activity that causes more perspiration. Socks that can wick the moisture are mostly constructed from synthetic materials like polyester, nylon, spandex, and Lycra. Synthetic fibers don’t absorb moisture, which in turn reduces chafing and blisters. Although some natural fibers like merino wool are naturally breathable, we were unable to identify any merino wool socks that fit the criteria for our list since they didn’t sit high enough on the leg to allow for the comfortable use of kneepads. While playing volleyball, the players are often required to cut-and-jump, and hence enhanced padding in the heels and under the balls of the feet is expected from socks [95].

10 Pads and Helmets

Traditionally, cane, leather, and cotton were used as cricket pads, while modern cricket knee pads are made up of high-density foam, which makes them secure, lightweight, and easy to wear. Shins, ankles, and knees of the batsmen are protected by modern batting pads, which are fastened to the leg by straps that go around the calf. Additional pads are used around other parts of the bodies depending upon the protection that a player expects while playing. High-density foam is utilized for several reasons that include lighter in weight and easy to transport. A wicket-keeper in the cricket is required to wear knee and shin pads for better protection that are thinner than the pads used by the batsmen for better movement and to reduce the likelihood that a ball would get stuck between the knee roll and the thigh [96].

In the case of hockey, the players endure high amounts of force while checking or being checked that leads to significant injuries. In order to protect themselves from injuries, players wear helmets and pads. A goaltender becomes vulnerable and may lose the balance if they wear the improper pads. Hockey pads often are made up of a hard outer shell with softer inner shell for cushioning, similar to football pads. Outer shell is made to disperse the force of the strike and prevent it from being concentrated in a specific region, while inner pad is often constructed of foam that facilitates in lowering the force, which a player might encounter after a collision. The foam structure makes the collisions less elastic, as kinetic energy is transformed into other types of energy (heat) which lessens the impact.

Hockey goalie pads differ slightly from regular hockey pads, comprising of thicker foam, without differentiating hard outer layer. While goalie pads aid in shock absorption and injury prevention, they are also made to prevent pucks from deflection. Goalie pads are made of thicker foam than ordinary hockey pads, which makes collisions even less elastic and causes even more kinetic energy to be converted into other kinds of energy, reducing the puck's ability to rebound as far [97].

11 Wrist Bands and Helmets

The main purpose of wristbands is to absorb sweat of the players and prevent it from getting on their hands, e.g., tennis players or athletes. The wristbands that athletes wear come in a variety of designs, and their sporting activities benefit from the ability to maintain surface friction and grip. Such comfort is crucial in the case of tennis, where the players must grasp racquets for extended periods of time. In addition, wristbands can also be used to wipe sweat from the forehead or face. Basketball players prefer using arm sleeves – an extended version of wristbands. Spandex is added to cotton and nylon combinations to offer enhanced performance and a perfect fit, while flexible width and sweat-absorbent properties of wristband are well-liked. Wristbands meant for badminton players, are made of extra-thick fabrics made of cotton (70%), polyester (23%), and elastane (6%) or cotton (80%), nylon (14%), elastane (5%) and viscose (1%) for soft texture, comfort and durability.

Helmets have a cushioned interior and a rigid exterior shell and are required for effective diffusion of shocks and to protect the brain and head of the players. Many helmets are equipped with visors or cages. Visors are composed of transparent plastics, designed to shield the face and eyes, while allowing clear vision, while cages completely enclose the face and are composed of metal or composite mesh. More protection is provided by cages at the expense of vision [98].

12 Conclusion

Developments in the manufacturing of newer fibers offer improvements in the manufacturing of synthetic sportswear, sporting surfaces, and accessories. Though synthetic surfaces do not support proliferation of microbes, periodic disinfection is recommended to control their population. However, in the case of artificial turfs, effect of creep, chemical and environmental degradation of grass surfaces, mechanical damages due to repeated sporting activities, and changes in the properties of infill substances due to prolonged use of such surfaces need careful analysis. Developments in manufacturing processes enhance the comfort levels provided by various sports accessories and improve their performances.

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