

Application of technical textiles in sports

Primjena tehničkog tekstila u sportu

Review paper / Pregledni rad

Silvana Zhezhova¹, Sonja Jordeva¹, Sanja Risteski¹, Sashka Golomeova Longurova¹ and Vangja Dimitrijeva-Kuzmanoska²

¹Goce Delcev University, Faculty of Technology, Stip, North Macedonia

²Goce Delcev University, Art Academy, Stip, North Macedonia

*Correspondence: silvana.zezova@ugd.edu.mk

Abstract

Textile materials are used in all kinds of sports as sportswear in the form of shorts, T- shirts, tracksuits, swimwear, compression garments etc. Except for making clothes, textiles are used as an integral part of sports equipment or part of sports footwear. Also, technical textiles are widely used for production of sports accessories to provide additional comfort, support, and functionality. The application of textile composites in sports equipment has proven to be very useful, not only for improving overall performance but also in controlling every possible feature, leading to safer and fairer sports.

Sports textile is a growing industry and participates with 7.3 % in the global technical textiles market. Generally, textile materials used in sportswear have high heat and moisture transport capacity, lightweight, fast-drying capacity, and elasticity. These materials also have superior strength and durability. The latest textile materials used to make sportswear have different functional properties in order to meet the specific requirements in various sports activities. Consumption of textile materials in sports has increased significantly in the last few decades. This is due to the growing interest of the world population in sports and fitness activities, coupled with growing awareness of the importance of active lifestyles, drives demand for sportswear and equipment.

Keywords: sportswear; sports equipment; wearable comfort; textile structures

Sažetak

Tekstilni materijali se koriste u svim vrstama sporta kao sportska odjeća u obliku kratkih hlača, majica, trenirki, kupaćih kostima, kompresijske odjeće itd. Osim za izradu odjeće, tekstil se koristi kao sastavni dio sportske opreme ili kao dio sportske obuće. Također, tehnički tekstil se široko koristi za izradu sportskih dodataka za dodatnu udobnost, podršku i funkcionalnost. Primjena tekstilnih kompozita u sportskoj opremi pokazala se vrlo korisnom, ne samo za poboljšanje ukupne izvedbe, već i za kontrolu svih mogućih značajki, što dovodi do sigurnijeg i poštenijeg sporta. Različite primjene zahtijevaju različite kombinacije materijala, značajki dizajna i proizvodnih procesa.

Sportski tekstil je industrija koja raste i sudjeluje sa 7,3 % na svjetskom tržištu tehničkog tekstila. Općenito, tekstilni materijali koji se koriste u sportskoj odjeći imaju visoku sposobnost prijenosa topline i vlage, lagani su, brzo se suše i elastični su. Ovi materijali također imaju vrhunsku čvrstoću i izdržljivost. Najnoviji tekstilni materijali koji se koriste za izradu sportske odjeće imaju različita funkcionalna svojstva kako bi zadovoljili specifične zahtjeve u raznim sportskim aktivnostima. Potrošnja tekstilnih materijala u sportu značajno je porasla u posljednjih nekoliko desetljeća. To je zbog sve većeg interesa svjetske populacije za sportske i fitness aktivnosti, zajedno s rastućom svijesću o važnosti aktivnog načina života, što potiče potražnju za sportskom odjećom i opremom.

Ključne riječi: sportska odjeća; sportska oprema; udobnost nošenja; tekstilne strukture

1. Introduction

The term technical textile refers to all types of linear, two-dimensional and three-dimensional products that are used in various industries primarily for their performance or functional characteristics, not for their aesthetic and decorative properties [1, 2].

The technical textile combines both performance and decorative properties and functions in equal measure and is designed to have huge spectrum of certain properties, which makes them suitable for application in different industries [3].

According to the application and end-user industry, technical textiles are classified into twelve categories (Figure 1): agro textiles (agrotech), construction textiles (buildtech), clothing textiles (clothtech), domestic textiles (homotech), geo-textiles (geotech), industrial textiles (indutech), medical textiles (meditech), textiles used in transport (mobitech), packaging textiles (packtech), protective textiles (protech), sports textiles (sportech) and environmentally-friendly textiles (oekotech) [4, 5].

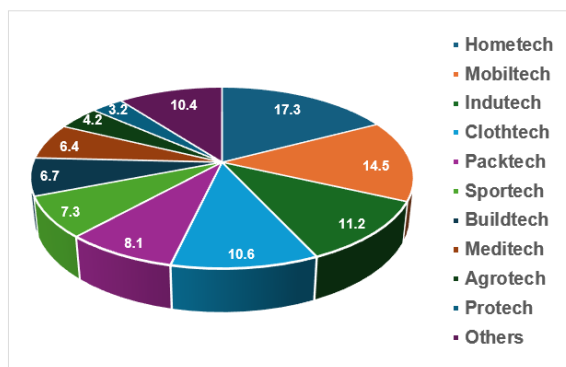


Figure 1. Global Technical textile market share in percentage categorized according to end users in 2011 [5]

These textiles are the fastest growing sector in the textile industry, because it is growing at twice the rate of textiles for clothing applications. The global textile market size was valued at USD 992.6 billion in 2021 and is predicted to be worth around USD 1,320.3 billion by 2030, registering a CAGR of 3.9% during the forecast period 2022 to 2030 (Figure 2), [6]. The global technical textile market was valued at USD 180.97 billion in 2021 and to reach around USD 272.5 billion by 2030 with a CAGR of 4.65% from 2022 to 2030 (Figure 3). It is projected to reach 207.42 billion by 2024 and this shows that the market of technical textile is

increasing significantly and it is estimated to become one fifth from global textile market [7]. This is due to the growing demands for functional textiles from various type of industries, new technological achievements and new innovations in almost all segments.

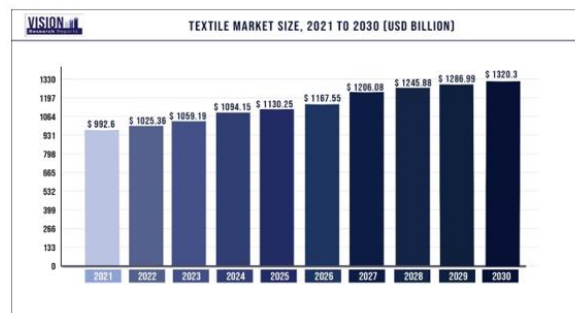


Figure 2. Global textile market size, 2021 to 2030 (USD BILLION) [6]

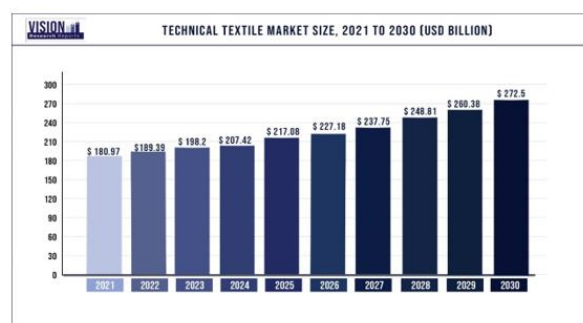


Figure 3. Global technical textile market size, 2021 to 2030 (USD BILLION) [7]

Asia-Pacific region is the largest technical textile market accounting for almost half of the value and is expected to remain so in the forecast period. The market in Europe is expected to grow at a significant CAGR over the forecast period, driven by Buildtech, Indutech, Mobiltech, Oekotech and Sportech segments. Also is expected to grow the North America's and Latin America's market driven by growing demand for technical textiles such as Meditech, Mobiltech, Indutech and Protech. Rising technical textiles demand is expected to drive the regional market in Middle East & Africa. Growth in the application of technical textiles is expected in segments such as Indutech, Meditech, Mobiltech, Protech and Sportech compared to other sub-segments [7].

2. Sports textiles

The sports textile sector is divided into three main categories: sportswear, sports equipment, and sports accessories [8]. Textile materials are used i

all kinds of sports (handball, football, tennis, athletics, aerobics, etc.) as sportswear in the form of breathable shorts, moisture-wicking shirts, tracksuits, swimwear, compression garments etc. Except for making clothes, textiles are used as an integral part of sports equipment (backpacks, bags, gloves, etc.) or part of sports footwear (athletic sneakers, hiking boots) [9, 10]. Also, technical textiles are widely used for production of sports accessories (socks, headbands, arm sleeves) to provide additional comfort, support, and functionality [11].



Figure 4: Different component of sports footwear [9, 10]

Sports textile is a growing industry and participates with 7.3 % in the global technical textiles market (Figure 1), [5]. Consumption of textile materials in sports has increased significantly in the last few decades. This is due to the growing interest of the world population in sports and fitness activities, coupled with growing awareness of the importance of active lifestyles, drives demand for sportswear and equipment.

According to the specific purpose of use, sportswear can be classified into four groups [12, 13]:

- functional sportswear;
- basic sportswear;
- casual sportswear for leisure and
- fashion sportswear.

Functional sportswear is clothing with advanced properties that improve performance through particular functionality. These clothes are intended for people that actively participate in sports. Basic sportswear has a more appealing, cheaper and trendier design, while casual sportswear is a replica of functional sportswear, mainly worn at home when less physical activity and sweating are expected. Fashion sportswear is created with most attention paid to modern design and clothing attraction as a result of the cooperation between

famous fashion designers, fashion houses and sports brands [14]. Consumers have specific requirements for different types of sportswear, for example: to have resistance to rain, snow, wind, but at the same time to be comfortable and to allow to move freely. Also, they have higher requirements in terms of clothing design and easy care in all types of clothing. Sport products such as clothing and footwear should be useful to the consumers themselves and include valuable properties such as strength, flexibility, thickness, durability, strength, moisture resistance and, most importantly, an appropriate price. Generally, textile materials used in sportswear have high heat and moisture transport capacity, lightweight, fast-drying capacity, and elasticity. These materials also have superior strength and durability. The latest textile materials used to make sportswear have different functional properties in order to meet the specific requirements in various sports activities.

The application of textile composites in sports equipment is a relatively new area. Their use in sports equipment has proven to be very useful, not only for improving overall performance across a wide range of activities but also in controlling every possible feature, leading to safer and fairer sports. Different applications require different combinations of materials, design features and production processes [15].

There has been an intrinsic change in the sport textile sector with a parallel evolution in the technology used. The integration of electronics and sensors into sport textiles has further expanded the role of technical textiles in sports. Smart fabrics embedded with sensors, conductive yarns, and electronic components enable athletes' real-time data on performance metrics such as heart rate, hydration levels, and biomechanics. Smart garments, enhancing the overall experience for athletes and coaches, helping athletes to optimize their training and to prevent potential injuries. As technology continues to advance, we can expect further innovation and growth in the use of technical textiles in sports-related products and applications [16, 17].

3. Comfort when wearing sports clothes

Sports activities, regardless of whether they are high-level sports competitions or leisure activities, include an element of strain on both systems: the muscular and the thermo-physiological system [18].

Therefore, it is especially important that clothing does not cause strain; the opposite of this, if possible, to help the athlete to achieve better results and prevent possible injuries.

That's why comfort when wearing sportswear is an important criterion for quality. It affects not only the comfort of the wearer, but also the performance and efficiency of the garment. For example, if an active sports person wears clothing with low porosity, heart rate and body temperature will increase much faster than when wearing breathable sports clothing [19].

Wearing comfort is also one of the most important selling aspects. "World Sports Activewear" magazine points out that, "comfort is the most important thing in clothing and it comes from sportswear where consumers have become accustomed to comfort. 94 % of consumers would like their clothes to be comfortable, i.e. comfort is number one in consumer expectations" [20].

Wearing comfort is a complex phenomenon, but it can generally be divided into four different main aspects [21, 22]:

1. The first aspect is referred to as thermophysiological wearing comfort and directly affects the person's thermoregulation, including the processes of heat and moisture transport through clothing. Key processes include thermal insulation, air permeability and moisture management.

2. The skin sensorial comfort characterized by the mechanical feeling, which the textile material causes in direct contact with the wearer's skin. This perception can be pleasant, such as smoothness or softness, but also the perception can be unpleasant, if the fabric causes itching, if it is too stiff or clings to the sweaty wet skin of the wearer.

3. Ergonomic wearing comfort refers to the fit of the garment and the freedom of movement that the garment allows. Ergonomic wearing comfort mainly depends on the model of the garment and the elasticity of the material.

4. The fourth aspect is physiological wearing comfort, which is one of the most important aspects. It is influenced by personal fashion requirements of the consumer for color, cut and design, ideology, etc.

Market research shows that the majority of sports participants consider wearing comfort to be the most important feature of clothing intended for sports or fitness activities. It is believed that elastic fibers will pave the way to more comfortable

clothing [21, 22]. Other preferred properties are: freedom of movement, breathability, machine washable, durability, adaptability and lightweight (Figure 5).

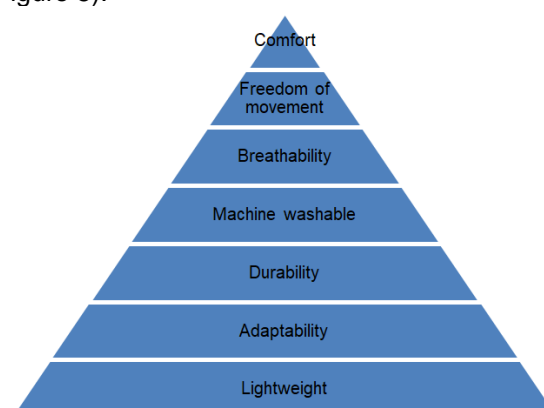


Figure 5. Important properties of clothing intended for sports or fitness activities [21]

4. Important features of sportswear

Textiles play a fundamental role in every aspect of sports, from apparel and footwear to protective gear and equipment. With the application of innovative materials, sustainable technologies, and design principles, sports textiles help athletes achieve their full potential while staying comfortable, safe, and environmentally conscious [22, 23]. The most important properties of sports textiles include:

1. **Moisture Management:** Effective moisture management is crucial in sports textiles to wick sweat away from the body, keeping athletes dry and comfortable during intense physical activity. Fabrics with moisture-wicking properties, like polyester and polypropylene help regulate body temperature and prevent the buildup of moisture, reducing the risk of chafing, irritation, and odor [24].
2. **Breathability:** Ventilation is essential in sportswear to prevent overheating. Technical textiles are often engineered with breathable membranes or mesh panels to allow air to circulate freely, enhancing ventilation and promoting airflow to regulate body temperature during exercise. Breathable sports textiles help keep athletes cool, dry, and comfortable, particularly in hot and humid conditions [24].
3. **Stretch and Recovery:** Sports textiles should have sufficient stretchability and elasticity to allow athletes to move freely and perform dynamic movements without restriction.

- Fabrics with good stretch and recovery properties maintain their shape and fit over time, ensuring comfort and performance during intense physical activity [25].
4. **Compression:** Compression garments made from specialized elastic textile materials like spandex provide targeted support to muscles, improve blood circulation, reduce muscle vibration, enhance recovery, and prevent injury during training and competition. These type of materials are widely used in sportswear, especially in sports where muscle performance is critical, such as running, cycling, and basketball [26].
 5. **Thermal Regulation:** Technical textiles can also help regulate body temperature in extreme conditions. Fabrics with insulating properties, like thermal layers or reflective coatings, keep athletes warm in cold weather while cooling fabrics dissipate heat and moisture to keep athletes cool in hot conditions.
 6. **Durability and Abrasion Resistance:** Sports textiles need to withstand the rigors of athletic performance, frequent washing, and wear and tear. Technical textiles are engineered to be durable and resistant to abrasion, tearing, and pilling ensuring they can withstand the rigors of sports performance over time.
 7. **Lightweight Construction:** Lightweight textile materials minimize the burden on athletes, allowing them to move freely without being weighed down by heavy clothing or equipment. Lightweight sports textiles enhance agility, speed, and comfort, particularly in sports that require speed and agility, like running and cycling.
 8. **Protection and Safety:** Sports textiles provide athletes with protection against environmental elements, impact, and injury. In sports where injury risk is high, such as skiing, snowboarding, and motorcycling, technical textiles are used to provide protective gear such as helmets, body armor, and padding. These specialized materials help reduce the risk of injury and enhance safety during contact sports and high-risk activities. UV-protective sports textiles help athletes stay safe and comfortable during prolonged sun exposure and shield athletes from harmful ultraviolet (UV) rays during outdoor activities, reducing the risk of sunburn, skin damage, and long-term health effects.
 9. **Biomechanical Enhancement:** Some technical textiles are designed to improve biomechanical efficiency and performance. Smart textiles, like fabrics with integrated sensors or conductive yarns can provide real-time feedback on body movement and posture, helping athletes optimize their technique.
 10. **Antimicrobial and Odor Control:** Antimicrobial textile materials inhibit the growth of odor-causing bacteria, fungi, and microbes, keeping sportswear fresh and odor-free even after prolonged use and enhance hygiene, comfort, and confidence for athletes during training and competition.
 11. **Environmental sustainability:** There is a growing emphasis on sustainability in the sportswear industry. Increasingly, sports textiles are designed with environmentally friendly materials and sustainable manufacturing processes in order to reduce the harmful impact on the environment. Sustainable sports textiles include the application of recycled fibers, biodegradable materials and environmentally responsible manufacturing practices to minimize environmental impact and to promote sustainability and carbon reduction [25, 26, 27].

5. Textile structure used in sports textiles

Different types of sports require different types of sportswear with adequate properties suited to the demands of athletic performance. It is not possible to achieve all the necessary properties for sportswear in a simple structure of any fiber. By selecting and combining appropriate textile structures and construction methods, sportswear manufacturers can create garments and equipment tailored to the specific needs of athletes in different sports and activities [28, 29]. To produce sports textiles, a variety of fibers, both natural and synthetic, can be used, each offering different properties. Synthetic fibers dominate the sports textile industry due to their exceptional performance properties, versatility, and affordability. The most commonly used synthetic fibers are polyester, nylon, spandex (elastane), and polypropylene. These fibers account for 60 % to 70 % or more of the overall fiber content in sports textiles. These fibers offer a wide range of benefits for athletic apparel, including moisture-wicking, quick-drying, durability, stretchability,

and lightweight construction, making them well-suited for various sports and activities.

Polyester is one of the most widely used synthetic fiber in sports textiles due to its excellent moisture management properties, dimensional stability, durability, easy care properties and affordability. It is commonly used in base fabrics for active wear like tops, shorts, jackets, and accessories.

Nylon is another synthetic fiber used in sportswear for its lightweight, high strength and softness, abrasion resistance and elasticity. It is commonly blended with other fibers to enhance durability and stretchability in garments such as leggings, tracksuits, shorts, and outerwear.

Spandex is ideal for production of compression garments and activewear where freedom of movement is essential because of its exceptional elasticity and stretch recovery.

The use of natural fibers in sports textiles has decreased over time with the rise of synthetic fibers offering superior performance characteristics for athletic apparel. However, natural fibers like cotton, wool, and bamboo are still used in some sportswear for their comfort, breathability, and sustainability properties.

Cotton garments provide a good combination of softness and comfort, and it is used in casual sportswear, t-shirts, and leisure wear. Bamboo fibers are also gaining popularity in sportswear for their antibacterial, moisture-wicking, and eco-friendly attributes. In general, bamboo fiber can be used for practically every application in which cotton is used. Some manufacturers prefer this type of cotton fabric primarily because of its significant attributes that benefit production and manufacturing processes.

Wool is known for its natural moisture-wicking, temperature-regulating, and odor-resistant properties, making it suitable for base layers, socks, and cold weather sportswear. Merino wool, is usually used for running apparel and bicycle wear.

In sports textiles, a wide range of woven, knitted and nonwoven textile materials are commonly used, each offering unique properties suited to specific applications and performance requirements. Generally, for sportswear knitted textile materials are preferred due to their greater elasticity and stretch ability [30]. With appropriate combinations of yarns and fabrics and with new developments in fabric construction, knitted textile materials ideal for active sportswear can be produced. Multi-layer knitted fabrics are especially

popular for the production of sportswear. This is primarily due to their improved thermoregulatory properties because each layer has a special task [31, 32].

6. Conclusion

Sports textiles are one of the fastest growing areas of application of technical textiles. In the twenty-first century, clothing plays an important role for consumers who are actively involved in sports, as well as for those who are physically active in their free time. The consumption of textile materials in sports has seen a significant increase in the last few decades. This is due to recent advances in the field of sports textiles and future development trends.

The textile materials used to make sportswear have different functional properties in order to satisfy the specific requirements in different sports activities. In general, textile materials used to make sportswear should possess some of the following characteristics: optimal heat and moisture regulation, good air and water vapor permeability, fast moisture absorption and transfer capacity, quick drying ability and returnability, ductility, dimensional stability in wet condition, superior strength and durability, light weight, easy maintenance capability, durability, soft and pleasant touch. It is not possible to achieve all these properties in a simple textile structure. By selecting and combining appropriate textile structures and construction methods, sportswear manufacturers can create garments and equipment tailored to the specific needs of athletes in different sports and activities. The growing representation of textile materials in the sports market is also due to the development of the science of textile fibers and polymers, as well as the development of technologies for the production of new types of high-performance fibers, knitted and woven fabrics.

The integration of electronics and sensors into sports textiles has further expanded the role of technical textiles in sports. Smart garments, enhancing the overall experience for athletes and coaches, helping athletes to optimize their training and to prevent potential injuries. As technology continues to advance, we can expect further innovation and growth in the use of technical textiles in sports-related products and applications.

References

- [1] Horrocks A. R., Anand S. C.: Handbook Of Technical Textiles, Woodhead Publishing Limited 2000, 559
- [2] Sheraz A., Abher R., Yasir N.: Fibers for Technical Textiles, Springer Cham 2020, 220
- [3] Zhezhova S., Risteski S., Jordeva S., Srebrenkoska V.: Medical textiles, possibilities and challenges, Zbornik radova Naučna konferencija SANUS, Prijedor 2022, 275-283
- [4] Rasheed A.: Classification of Technical Textiles. In Fibers for Technical Textiles, Springer 2020, 49-64
- [5] Rogina-Car B., Kopitar D., Schwarz I.: Protective Properties of Health Care Materials Influenced by the Application Conditions, Textile & Leather Review **1** (2018.) 1,18-28
- [6] <https://www.visionresearchreports.com/textile-market/39190>, Accessed: 2024-20-05
- [7] <https://www.visionresearchreports.com/technical-textile-market/39283>, Accessed: 2024-21-05
- [8] Senthil Kumar R., Sundaresan S.: Textiles in sports & leisure, Asian Textile Journal, 21 (2012.) 9, 44-49
- [9] Roy R., Udhayakumar G.; Bhardwaj P.: The Role of Textile Materials in Sports Footwear: A Comprehensive Review, Advance Research in Textile Engineering **8** (2023.) 1, 1081
- [10] <https://www.fleetfeet.com/blog/running-shoe-anatomy-6-parts-that-shape-comfort-and-performance>, Accessed: 2024-03-06
- [11] Ahmad F. et al.: Recent developments in materials and manufacturing techniques used for sports textiles, International Journal of Polymer Science **2023** (2023.) 20 pages
- [12] Hayes S. G., Venkatraman P.: Materials and Technology for Sportswear and Performance Apparel, CRC Press, Taylor & Francis Group 2016, 382
- [13] Stojanović S., Geršak J.: Textile materials intended for sportswear, Tekstil **68** (2019.) 4-6, 72-88
- [14] Manshahia M., Das A.: High active sportswear – A critical review, Indian Journal of Fibre & Textile Research **39** (2014.) 441-449
- [15] Chowdhury P., Samanta K. K., Basak S.: Recent Development in Textile for Sportswear Application, International Journal of Engineering Research & Technology **3** (2014.) 5, 1905-1910
- [16] Yang, K., McErlain-Naylor, S. A., Isaia, B., Callaway, A., Beeby, S.: E-Textiles for Sports and Fitness Sensing: Current State, Challenges, and Future Opportunities, Sensors **24** (2024.) 4, 1058
- [17] <https://www.mordorintelligence.com/industry-reports/global-smart-fabrics-for-sports-and-fitness-market-industry>, Accessed: 2024-03-06
- [18] Bartels V. T.: Improving comfort in sports and leisure wear. In Improving Comfort in Clothing, Woodhead Publishing Series in Textiles 2011, 385–411

- [19] Kumar C. S., Senthil Kumar B., Anita Rachel D.: Comfort aspects of sportswear base fabrics: a review, *Journal of Emerging Technologies and Innovative Research* **7** (2020.) 2, 1071-1076
- [20] Foster L.: Sportswear 2000 – Interpreting fabric trends, *World Sports Activewear* 4 (1998.) 3, 21-24
- [21] Shishoo R.: *Textiles in Sport*, Woodhead Publishing, Cambridge England 2005, 177-202
- [22] Ziemele I., Šroma I., Kakarane A.: Comfort in sportswear, *Key Engineering Materials* **762** (2008.) 402-407
- [23] Jordeva S., Cortoseva S. Kaloyanov N.: Termo-fiziološki komfor dvoslojnih pletenina, *Tekstilna industrija*, **60** (2012.) 4, 11-19
- [24] El Mogahzy Y. E.: Development of traditional textile fiber products. In *Engineering Textiles*, Woodhead Publishing 2009, 329-397
- [25] Rossi, R. M.: High-performance sportswear. In *High-Performance Apparel*. Woodhead Publishing, 2018, 341-356
- [26] Yip J.: *Latest Material and Technological Developments for Activewear*, Woodhead Publishing 2020, 230
- [27] Harlin A., Jussila K., Ilen E.: *Sports Textiles and Comfort Aspects*, High Performance Technical Textiles, John Wiley & Sons Ltd. 2019, 37-67
- [28] Venkatraman P.: Fibres for sportswear. In *Materials and technology for sportswear and performance apparel*, CRC Press 2016, 23-52
- [29] Turukmane R., Daberao A.: Review - Textile fibres for sports applications, *Journal of the Textile Association* **84** (2023.) 1, 21-23
- [30] Shishoo R.: Introduction to textiles in sport. In *Textiles for Sportswear*, Woodhead Publishing 2015, 3-16
- [31] Grishanov S.: Structure and properties of textile materials. In *Handbook of Textile and Industrial Dyeing*. Woodhead Publishing 2011, 28-63.
- [32] Özdil N., Anand S.: Recent developments in textile materials and products used for active wear and sportswear, *Electronic Journal of Vehicle Technologies* **8** (2014.) 3, 68-83