

REVIEW ARTICLE

The place and importance of nanotechnology in sports

Ramazan Göğebakan *Faculty of Sports Sciences, Selçuk University, Türkiye.*

Abstract

Received:
April 18, 2025

Accepted:
May 26, 2025

Online Published:
June 27, 2025

Keywords:
Nanotechnology, sports,
technology.

In today's world, nanotechnology holds significant importance both in daily life and in the field of sports. With the advancement of technology, nanotechnology has gained increasing prominence, particularly within the sports industry. Due to its usability in terms of performance, safety, and comfort, interest in nanotechnology continues to grow day by day. This study presents examples of materials used in sports that incorporate nanotechnology, aiming to create safer sporting environments alongside enhanced athletic performance through these products. The demand for sports products that offer improved performance and efficiency has been evident for many years, and nanotechnology has opened new avenues for the development of functional sportswear and equipment. The primary objective of this study is to provide a general overview of the applications of nanotechnology across various areas of sports, with a particular focus on sports surfaces, clothing, equipment, and footwear. Additionally, the study explores in detail several key properties imparted to sportswear through nanotechnology. In line with current trends, it is anticipated that all types of sports equipment will undergo a nanotechnological revolution in the near future.

Introduction

The term "nano" is derived from the Greek word *nannos*, meaning "dwarf" or "very small man." In the metric system, "nano" is used as a unit of measurement and refers to one-billionth of a unit in scientific terms (Allhoff et al., 2017). When materials are reduced to the nanoscale, quantum effects begin to dominate, and discontinuous changes in physical properties occur (Çıracı, 2007). In these nanostructures, when electrons are confined within a few nanometers, new quantizations arise depending on the general geometry, significantly altering the known mechanical and electronic properties of the material. Nanoscience helps us understand this new behavior emerging at extremely small scales through quantum theory. Nanotechnology, on the other hand, aims either to design and optimize new properties and nanostructures or to make existing nanostructures and molecules more functional and applicable in various domains (Çıracı, 2007).

With the increasing use of nanotechnology in nearly every field today, the application of nanomaterials in sports engineering has also gained importance and contributed to the advancement of sports technologies.

Nanotechnology is now widely utilized in various areas of sports, including sports venues, equipment, coatings, flooring, and apparel. Renowned sports companies are seeking innovative ideas to enable athletes to achieve better results and to meet desired performance criteria through the use of nanotechnology (Jiang & Wang, 2013).

Currently, sports facilities have undergone major transformations with the use of nanomaterials in the construction of stadium roofs, floors, walls, and glass components. Nanofilms with high resistance to water and moisture are applied to stadium floors and walls to prevent rust and surface defects, maintain long-term cleanliness, and extend the materials' lifespan (Zhi-gang, 2013). Painting stadium walls with antibacterial, self-cleaning, and stain-repellent nano-paints containing SiO₂ nanoparticles purifies indoor air, provides thermal benefits, and offers protection against ultraviolet (UV) radiation (Kai, 2013).

Sports products containing different types of nanoparticles offer advantages such as higher performance, increased durability, and lightweight properties (Jiang & Wang, 2013). This not only positively affects athletes but also helps reduce potential

✉ R. Göğebakan, e-mail: rgogebakan46@gmail.com

To Cite: Göğebakan, R. (2025). The place and importance of nanotechnology in sports. *J Innov Technol Hum Kinet*, 3(1), 11-16.

risks and damage. Carbon nanotubes are used in tennis and badminton rackets to reduce weight, improve feedback and control, and enhance material strength. These rackets are generally made from graphite and carbon fibers. Tennis balls coated with nanoparticles like nanoclay experience reduced air leakage due to gas barrier effects, thus significantly extending their lifespan. Carbon nanotube-framed bicycles combine lightness with high rigidity. Another example includes high-speed boats with nanoparticle coatings that reduce resistance and enhance performance (Bao-feng, 2013).

The increasing role of nanotechnology in the textile industry has led to the development of a variety of high-value, quality products (Patra & Gouda, 2013). The treatment of textile materials with various nanoparticles and the production of nanofibers have revolutionized the sportswear market. Nanoparticles on textile surfaces impart unique multifunctional properties without negatively affecting breathability or tactile sensation (Nazari, 2005). Some of the broad applications of nanotechnology in sports apparel include odor-eliminating, waterproof, and antibacterial sports shoes, water-resistant swimsuits, and high-impact-resistant protective clothing. Nano-sportswear enhances athletic performance and physical comfort. Textiles equipped with electronic sensors and Global Positioning Systems (GPS) support athletes in monitoring and optimizing their training and performance (Nazari, 2005).

Technology

The role of technology in sports has significantly evolved since the beginning of the century, in parallel with technological advancements and digitalization across other sectors. This transformation, driven by the emergence of the internet and mobile technologies, has made technology indispensable in many branches of sports (Ratten, 2019). Technology has played a vital role in the pursuit of excellence both on and off the field, making sports more thrilling and challenging than ever before (Schmidt, 2020).

Historically, sport was primarily seen as a leisure activity. However, the rise of technology-oriented international agreements and professionalization has led to major changes: fans and consumers can now follow their favorite teams and athletes almost anytime and anywhere in the world through digital technology or social media, either live or on demand. Athletes today have access to a much broader range of sports disciplines compared to the past and are less dependent on other players or limitations. In their pursuit of

enhancing performance, they make extensive use of technology (Ratten, 2011).

It is often believed that in many sports disciplines, the limits of human physical capability have already been reached (Berthelot et al., 2008). "In the future, the boundaries of athletic performance will be determined more by scientific and technological advancements than by the athlete's innate physiology" (Lippi et al., 2008). In most professional sports, it is assumed that significant future improvements will, to some extent, depend on technology (Balmer et al., 2012). Naturally, these advancements and possibilities raise various ethical concerns, which are also discussed in the literature (Dyer, 2015).

Technological developments in sports affect not only athletes and consumers but also sports managers, who must now operate in and compete within an increasingly complex industry. Historically, sport was predominantly governed by public or voluntary organizations, and the presence of professional or commercial institutions was limited. However, given the rapid developments and growth in the sports industry over recent decades, the pressure to adopt market mechanisms has continually intensified (Misener & Misener, 2017).

Nanotechnology

Nanotechnology has been applied to tennis rackets, badminton rackets, and table tennis paddles to reduce their weight while enhancing their flexibility, durability, and overall feel during use. For instance, the Wilson nCod tennis racket was produced by filling the pores of a carbon fiber composite with nano-SiO₂, resulting in a more homogeneous material structure with improved density and strength. The Williams sisters and Roger Federer used this racket during the French Open. Additionally, the Japanese company SRI developed the Aerogel 4D™ tennis racket, which is only three times heavier than air but possesses a density 4,000 times greater than its weight. Furthermore, YONEX successfully inserted "Vladislav Lun" particles (0.7 nm) into the interatomic spaces of carbon fibers, significantly reinforcing the racket's core components. As a result, the racket's impact resistance was increased by 30%, durability by 10%, rebound performance by 5%, and stability by 200%, thereby greatly enhancing its usability (Yu et al., 2006).

The sports industry has promoted extensive research and development (R&D) in smart multifunctional material engineering and nanotechnology to improve athletic performance, sports equipment, and flexible

strain sensors. This includes studies on advanced technological materials such as nanotextiles, conductive polymers, nanoparticles, carbon nanotubes (CNTs), and thin-film complex oxide nanostructures. Particularly, the direct integration of sensing capabilities into textile structures offers innovative and effective methods for monitoring the human body and environmental changes (Scherwitzl et al., 2009).

The high specific surface area of nanoparticles allows them to easily adhere to the surface of textile fabrics, and this coating process does not negatively affect the fabric's breathability or tactile properties. During the Shanghai Expo, a nano-waterproof fabric developed by the Institute of Physical Chemistry at the University of Zurich attracted significant attention. This fabric was produced from polyester fibers and coated with fibrillar silicate. The fibrillar silicate coating prevents rain from penetrating into the polyester fibers. Additionally, the air layer present in the gaps of the fibrillar silicate prevents water from coming into contact with the fibers. The nano-waterproof fabric remains dry even after being submerged in water for two months, making it considered the best waterproof fabric produced to date. Moreover, the resistance between the water and the fabric has been reduced by 20%. It is predicted that this fabric has great potential in swimsuit manufacturing. A new type of e-textile has also been successfully developed by immersing an ordinary fabric into a special nanoparticle solution. This e-textile not only conserves energy but also retains its mechanical properties, and it can also be utilized in the production of sportswear with movement response functionality (Lin, 2010).

Applications of nanotechnology in various sports branches and equipment



Figure 1. Diverse uses of nanotechnology in sports.

Tennis

When examining the fundamental elements of tennis, such as the racket and tennis ball, the innovations introduced by nanotechnology are striking. The French company Babolat increased the stiffness of its rackets fivefold compared to previous models by using nanotechnology and enhanced their durability through the use of crystals derived from silicon oxide in the racket frame. Similarly, Wilson began producing new-generation tennis rackets by advancing its investments in nanotechnology in 2004. These technological developments not only reduced the cost of nanotechnology-based rackets but also made them lighter and more durable. Furthermore, the vibration in rackets was minimized, and control was significantly improved. Focusing on tennis balls, Wilson has combined rubber with nanoclay particles through a nano-composite coating in its dual-core technology balls. This innovation created a gas barrier that maintained internal pressure, thereby extending the ball's lifespan and doubling its bounce capacity (Pektaş, 2016).



Figure 2. Tennis equipment utilizing nanotechnology.

Badminton

Sports equipment containing different nanoparticles offers higher performance, increased flexibility, durability, and the added benefit of being lightweight (Jiang and Wang, 2013). These properties positively affect athletes'

performance and help protect them from potential injuries. Carbon nanotubes are used in tennis and badminton rackets to reduce weight and enhance

flexibility, durability, and feel. These rackets are typically made from graphite and carbon fiber. Tennis balls coated with nanoparticles like nanoclay benefit from a gas barrier effect, significantly slowing down air leakage and prolonging the ball's usability (Bao-feng, 2013).



Figure 3. Badminton equipment utilizing nanotechnology.

Swimming

The LZR Racer swimsuit developed and produced by Speedo represents a major innovation in swimming performance enhanced by nanotechnology. The most notable feature of this swimsuit is its nanoparticle coating, which prevents water absorption and adds water-repellent properties, increases buoyancy, and minimizes friction to facilitate swimmer movement (Şentürk and Özer, 2022). It is widely acknowledged that this swimsuit played a significant role in Michael Phelps' record-breaking achievements (Devecioğlu, 2018). Inspired by shark skin and supported by NASA, the suit underwent various textile tests during development, and seams were joined to minimize drag (Sarman and Bulut, 2011). However, in 2010, the International Swimming Federation (FINA) banned swimsuits incorporating nanotechnology, arguing that they created unfair advantages among athletes. This decision was made to preserve the natural essence of sport and to prevent the manipulation of individual performance through technology (Türkmen and Mutlutürk, 2014).

Athletics

Sports shoes produced using nanoparticles are not only lightweight but also highly resistant to external impacts. These shoes were used in the 2008 Olympic Games, where an athlete finished second in the 400-meter race while wearing them. Running shoes developed with advanced technology offer greater flexibility and bending ability, which provide athletes with significant advantages during races. Additionally, they reduce energy loss and offer improved safety compared to traditional footwear (Devecioğlu & Altıngül, 2011).

Nanotechnology in Sports Surfaces

One of the significant applications of nanotechnology in the textile industry is in stadium flooring, which not only affects athletes' performance and safety but also enhances the durability and cleanliness of floor coverings (Su, 2014). It has been reported that nanomaterials used in gymnasium floors are effective not only in their strong water and oil repellency but also in terms of cleanliness (Zhao and Shen, 2012). Among the nanomaterials used in sports engineering are nano-carbon materials and nano-metal oxides (Chunyan et al., 2011). Calcium carbonate nanoparticles dispersed in polyurethane fibers increase

the elongation capability and thermal resistance of sports turf (Song and Cai, 2012). Nanoparticle-enhanced running tracks exhibit excellent rebound flexibility, recoverability after compression, elasticity, hardness, durability, flame resistance, mold resistance, and anti-static properties. Experimental evidence shows that the mechanical properties of nano-enhanced tracks are twice as high as those of regular polyurethane surfaces (Bao-feng, 2013).

Nanotechnology in Sports Shoes and Sportswear

The use of nanotechnology in textile materials, including nanofibers, nanocomposite fibers, and nano-coated textiles, adds multiple functionalities, enabling these materials to be used in the sportswear market. Many fabric manufacturers have utilized nanotechnology to develop a wide range of sportswear. The Swiss-based Scholler company has produced garments using nano-based technology that offers a balanced combination of comfort, air permeability, wind and water resistance, and self-cleaning properties, especially for extreme cold-weather sports such as mountaineering and skiing. These sportswear items are also noted for their rain and snow-repellent properties (Sawhney et al., 2008). UK-based JR Nanotech has developed "SoleFresh™" socks, treated with silver nanoparticles, which eliminate athlete's foot odor (Mohapatra et al., 2013). The Korean company Hyosung has produced nano-silver nylon fibers for use in sports apparel, sports bags, and running shoes for both daily activities and sports settings (Mohapatra et al., 2013). Nanotechnology has made a significant breakthrough in creating slip-resistant shoe soles (Baydal-Bertome, 2015). Thanks to nanotechnology, high moisture transfer sportswear that protects climbers from the cold and rain, as well as breathable garments

that regulate body temperature, have been developed (Miah, 2006).



Figure 4. Nanotechnology-based sports equipment used in swimming.

Conclusion

Nanotechnology has revolutionized many areas of sports engineering, including sports facilities, sports equipment, flooring, and clothing. In addition to its positive effects on individual sports, it has also influenced the performance of athletes in the Olympic Games. Sportswear equipped with nanotechnology offers multifunctional features such as protection against water, heat, cold, bacteria, and bad odors, while also being lightweight, flexible, and highly durable against impacts. The comfort of sports clothing has been positively affected by nanotechnology, which in turn enhances the athlete's performance and efficiency. Thanks to the breathability of nanosports clothing, athletes can sustain high levels of physical activity for longer durations.

In summary, compared to ordinary sports equipment and clothing, nanotechnology provides many advantages in the sports field. These advantages include:

- Increased athlete performance
- Enhanced athlete safety
- Increased athlete comfort
- Lightness and high durability
- Flexibility
- Multifunctional features such as waterproofing, antibacterial properties, odor prevention, stain resistance, UV protection, heat and cold protection
- Breathability

However, the potential negative impacts of nanoparticles on the user's skin and the environment should also be considered. Unfortunately, only a limited portion of research on nanoparticles has focused on

health, safety risks, and environmental threats. There are still unanswered questions regarding the impact of nanoparticle-based

products on human health and the environment. Future studies will likely focus on developing high-performance sportswear that minimizes health, safety, and environmental risks while adhering to safety regulations. Given the growing role of

nanotechnology and the increasing number of studies in this area, there is a rising demand for new methods and ideas to integrate nanotechnology into sports products. In recent years, the sportswear market has experienced significant growth, and innovative products are continuously developed with attention to performance, quality, and design. Consumers are willing to pay more for sportswear that offers both functional performance and stylish design, which makes it easier for them to gain a competitive advantage in their sports activities.

Future approaches will focus on meeting multifunctional requirements such as temperature regulation, friction reduction, moisture management, high durability, flexibility recovery, lightness, wind and waterproofing, and clothing comfort, depending on the nature of the sport, climate conditions, and physical activity. This will lead to the development of performance-enhancing products.

While nanofibers and nanocomposite fibers carry minimal risk, nano-coating processes—particularly the application of nanoparticles to textile surfaces—may present higher toxic risks. Therefore, durability in nano applications in the textile sector will be of great importance. Durable nano coatings in textile products will reduce the negative impacts of nanoparticles on health and the environment. In this context, the in-situ synthesis of nanoparticles on textile materials will allow for better adhesion of particles to the surface and ensure the durability of products even after prolonged use.

References

- Allhoff, F., Lin, P., & Moore, D. (2017). Nanoteknoloji nedir ve neden önemlidir. *Basım, TÜBİTAK Popüler Bilim Kitapları*, 901.
- Balmer, N., Pleasence, P., Nevill, A., 2012. Evolution and revolution: gauging the impact of technological and technical innovation on olympic performance. *J. Sports*

- Sci. 30 (11), 1075–1083. Dyer, B., 2015. The controversy of sports technology: a systematic review. *Springerplus* 4 (1).
- Baydal-Bertomeu, J. M., Puigcerver, S. A., González, J. C., Gomez, J., Perez-Fernandez, M., & Sempere-Tortosa, J. R. (2015). Nanotechnology can provide a real breakthrough in the anti-slip properties of safety footwear soles. *Footwear Science*, 7(sup1), S58-S60.
- Berthelot, G., Thibault, V., Tafflet, M., Escolano, S., El Helou, N., Jouven, X., & Toussaint, J. F. (2008). The citius end: world records progression announces the completion of a brief ultra-physiological quest. *PLoS One*, 3(2), e1552.
- Chunyan, L., Xingliang, L., Sijin, M., & Yanfen, X. (2011, August). Study on application and biosafety of nanomaterials in sports engineering. In *2011 International Conference on Future Computer Science and Education* (pp. 131-134). IEEE.
- Çıracı, S. (2007). A New Industrial Revolution in the 21st Century: Nanotechnology, *1 Mart 2007 (in Turkish)*.
- Devecioğlu, S., & Altıngül, O. (2011). Innovation in Sports Technologies. 6th International Advanced Technologies Symposium (IATS'11), 16-18 May 2011, Elazığ, Türkiye.
- Gong, Z. G. (2013). Nanotechnology application in sports. *Advanced materials research*, 662, 186-189.
- Jiang, Y. P., & Wang, Y. X. (2013). Study of sport devices based on nanomaterial. *Applied Mechanics and Materials*, 329, 75-78.
- Jiang, Y. P., & Wang, Y. X. (2013). Study of sport devices based on nanomaterial. *Applied Mechanics and Materials*, 329, 75-78.
- Kai, Y. (2013). Study of biosafety of nanomaterials in sports engineering. *Applied Mechanics and Materials*, 340, 348-352.
- Li, B. F. (2013). Design of sports field based on nanometer materials. *Applied Mechanics and Materials*, 340, 366-369.
- Li, B. F. (2013). Design of sports field based on nanometer materials. *Applied Mechanics and Materials*, 340, 366-369.
- Lin, L. (2010). New nanotechnology collection. *Technology and Market*, 17(4), 100-101.
- Lippi, G., Banfi, G., Favaloro, E. J., Rittweger, J., & Maffulli, N. (2008). Updates on improvement of human athletic performance: focus on world records in athletics. *British Medical Bulletin*, 87(1), 7-15.
- Miah, A. (2006). Rethinking enhancement in sport. *Annals of the New York Academy of Sciences*, 1093(1), 301-320.
- Misener, K.E., Misener, L., 2017. Grey is the new black: advancing understanding of new organizational forms and blurring sector boundaries in sport management. *J. Sport Manag.* 31 (2), 125–132.
- Mohapatra, H. S., Chatterjee, A., & Maity, S. (2013). Nanotechnology in fibers and textiles. *International Journal of Recent Technology and Engineering*, 2(5), 132-138.
- Nazari, A., Montazer, M., Rashidi, A., Yazdanshenas, M., & Anary-Abbasinejad, M. (2009). Nano TiO₂ photo-catalyst and sodium hypophosphite for cross-linking cotton with poly carboxylic acids under UV and high temperature. *Applied Catalysis A: General*, 371(1-2), 10-16.
- Patra, J. K., & Gouda, S. (2013). Application of nanotechnology in textile engineering: An overview. *J. Eng. Technol. Res.* 5(5), 104-111.
- Pektaş, N. (2016). Analyze of Technical Parameter During Simulated Competition on Tennis Players, Selcuk University, Health Sciences Institute, Master Thesis.
- Ratten, V. (2011). Sport-based entrepreneurship: towards a new theory of entrepreneurship and sport management. *International entrepreneurship and management journal*, 7, 57-69.
- Ratten, V. (2019). Sports technology and innovation. *Cham: Springer Books*, 95-111.
- Sarman, Ö. F., & Bulut, Ş. (2011). Nanotechnology in Sports (Ömer & Şafak, slideshare.net, p. 25) .
- Sawhney, A. P. S., Condon, B., Singh, K. V., Pang, S. S., Li, G., & Hui, D. (2008). Modern applications of nanotechnology in textiles. *Textile Research Journal*, 78(8), 731-739.
- Scherwitzl, R., Zubko, P., Lichtensteiger, C., & Triscone, J. M. (2009). Electric-field tuning of the metal-insulator transition in ultrathin films of LaNiO₃. *Applied Physics Letters*, 95(22).
- Schmidt, S.L., (2020). In: Schmidt, S.L. (Ed.), 21st Century Sports. Springer International Publishing.
- Song, Z. Q., & Cai, Y. T. (2013). Application of nanomaterials in sports engineering. *Advanced Materials Research*, 602, 281-284.
- Su, Q. F. (2014). Analysis of new materials in competitive sports. *Applied Mechanics and Materials*, 539, 925-927.
- Şentürk, E., & Özer, M. (2022). Tecnological developments in sports. *Fenerbahçe University Journal of Sport Science*, 2(2), 49-63.
- Türkmen, M., & Mutlutürk, N. (2014). The application of nanotechnology to the sports equipments and the assistance of it to the performance. *International Journal of Social Science Research*, 3(1).
- Yu, W., Hu, Y., Wang, K., Bian, Z., Yan, F., Ren, Y., & Zhou, Z. (2006). Applying nanotechnology to athletic sports. *Sports Science Research*, 27(3), 33.
- Zhao, H. E., & Shen, F. (2012). The applied research of nanophase materials in sports engineering. *Advanced Materials Research*, 496, 126-129.