

ORIGINAL

## Bibliometric Analysis of Sports Running Socks Made from Bamboo, Cotton, and Acrylic

### Análisis Bibliométrico de Calcetines Deportivos para Running elaborados con bambú, algodón y acrílico

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#### ABSTRACT

This bibliometric analysis examines sports socks for running made from bamboo, cotton, and acrylic, with a focus on comfort, durability, and sustainability in the sports field. This study analyzed the evolution of publications using the Scopus database, reviewing 153 documents since 1990. Using bibliometric tools such as Bibliometrix and VOSviewer, trends, patterns, and gaps in the scientific literature were identified, offering a comprehensive view of the development of knowledge in this area. The results show that the main focus of the research is on the relationship between the friction and thermoregulation properties of socks, aimed at preventing blisters and improving performance, especially in high-friction sports such as running. The driving themes identified include the impact on foot health, biomechanics, and athletic performance, while the basic themes analyze friction and the interaction between materials. Likewise, niche topics such as product design and antimicrobial properties emerge, reflecting a growing interest in the development of functional and sustainable materials. The citation trend highlights the relevance of early studies addressing the structure and properties of socks to prevent injuries and improve user comfort. The conclusions emphasize the need for more comprehensive research on the use of alternative materials and their impact on health and athletic performance, contributing to the advancement of sustainable, high-performance sports textiles.

**Keywords:** Bibliometrics; Sports Socks; Innovation in Sports Textiles; Sustainable Materials.

#### RESUMEN

Este análisis bibliométrico examina los calcetines deportivos para running (CDR) fabricados con bambú (BB), algodón (CO) y acrílico (PAC), con un enfoque en los temas de confort, durabilidad y sostenibilidad en el ámbito deportivo. Este estudio analizó la evolución de las publicaciones mediante la base de datos Scopus, revisando 153 documentos desde 1990, mediante herramientas bibliométricas como Bibliométrix y VOSviewer, se identificaron tendencias, patrones y vacíos en la literatura científica, ofreciendo una visión integral del desarrollo del conocimiento en esta área. Los resultados presentan que el origen principal de la investigación está en la relación entre las propiedades de fricción y termorregulación de los calcetines, orientada a prevenir ampollas y mejorar el rendimiento, especialmente en deportes como el running. Los temas motores identificados incluyen el impacto en la salud del pie, la biomecánica y el rendimiento deportivo, mientras que los temas básicos analizan la fricción y la interacción entre materiales. Asimismo, surgen temas de nicho como el diseño de productos y las propiedades antimicrobianas, lo que refleja un interés creciente en el desarrollo de materiales funcionales y sostenibles. La tendencia de citas resalta la relevancia de los estudios iniciales que abordan la estructura y las propiedades de los calcetines, con el fin de prevenir lesiones y mejorar el confort del usuario. Las conclusiones destacan la necesidad de realizar

investigaciones más exhaustivas sobre el uso de materiales alternativos y su impacto en la salud y el rendimiento deportivo, contribuyendo al avance de los textiles deportivos sostenibles y de alto rendimiento.

**Palabras clave:** Bibliometría; Calcetines Deportivos; Innovación en Textiles Deportivos; Materiales Sostenibles.

## INTRODUCTION

In recent years, the textile industry has driven research into functional materials for sportswear, spurred on by demand for sustainable, electronic, and high-performance products.<sup>(1)</sup> Sports socks made from bamboo (BB), cotton (CO), and acrylic (PAC) fibers have gained popularity for combining durability, comfort, and sustainability.<sup>(2,3,4)</sup> These materials not only improve comfort and fit, but also respond to the trends that dominate the textile market.<sup>(3)</sup> However, scientific and academic research on this topic is recent and scattered, which has created a need for an analysis of research trends and patterns in this area.

Bibliometrics, as an analytical tool,<sup>(4)</sup> allows us to analyze the evolution of research on BB, CO, and PAC running socks (CDR), facilitating the identification of driving themes, emerging areas, and collaboration networks between authors and disciplines. Several studies have examined specific topics, such as blister and friction prevention, foot thermoregulation<sup>(5,6)</sup>, and the antimicrobial properties of materials.<sup>(7,8)</sup> However, to date, no bibliometric analysis has been conducted to examine the research and, in turn, understand the dynamics and relationships among the different areas of knowledge in RSR.

Through the use of bibliometric tools and thematic map analysis,<sup>(8)</sup> this research explores the main thematic areas from multiple disciplinary perspectives, such as materials science, textile engineering, biomechanics, and sports medicine. The analysis of scientific output shows that studies in this area focus on user comfort and health, as well as the development of durable, functional textile materials, topics presented in the semantic map. Furthermore, the analysis of citations from initial documents shows that the most relevant publications have focused on improving friction and thermoregulation properties to prevent injuries in high-performance athletes.

This study aims to provide a holistic view of research into BB, CO, and PAC CDR through bibliometric analysis. The results identify trends, gaps, and opportunities that guide future research, advancing understanding of the field's evolution and driving innovation toward more sustainable, efficient textile products.

## General research question

How has scientific research on running socks evolved, and what are the trends and main contributions in terms of comfort, performance, and sustainability according to bibliometric analysis?

## Specific questions

- a) How many studies have been published over the years?
- b) Who are the most active authors in the field?
- c) What are the most relevant journals on the subject?
- d) From which areas of knowledge has research been conducted?
- e) What is the semantic development around the phenomenon under study?
- f) What are the driving themes surrounding the phenomenon under study, niche perspectives, and emerging topics?
- g) What are the historical roots of the central concept or construct of the subject under study?

## METHOD

A bibliometric analysis was used to examine advances in knowledge about running socks. This method involves systematic steps: formulating questions, identifying databases, developing an advanced search equation, and analyzing metadata.

The research adopted a quantitative approach at an exploratory and descriptive level. A non-experimental longitudinal design was chosen. A canonical search equation was constructed with key terms: ("running socks" OR "sports socks" OR "athletic socks" OR "performance socks" OR "running stockings") AND ("cotton" OR "bamboo" OR "acrylic" OR "natural fibers" OR "synthetic fibers" OR "textiles") AND ("comfort" OR "performance" OR "usability" OR "breathability" OR "fit" OR "thermoregulation" OR "moisture management"). It should be noted that this search strategy was not limited to a specific time period, as the aim was to understand the topic's development from its emergence in the scientific field to the present day. Scopus data was obtained for its multidisciplinary approach, identifying 153 scientific publications. The Scopus data was exported in text format and converted to Excel for processing. The raw and processed data are available at the links provided. Scientific map visualizations were created in the form of semantic and co-authorship networks, using specialized software such as Bibliometrix and VOSviewer.<sup>(9,10)</sup>

Bibliometrix is a tool developed in R, supported by the R Core Team and the R Foundation for Statistical Computing. It requires installing R and RStudio.<sup>(11)</sup> VOSviewer, developed by Leiden University, is open-source software for creating and visualizing bibliometric networks. It provides text-mining functionality to build co-occurrence networks of key terms.<sup>(12)</sup> The data are available in Mendeley Data and can be consulted at the following link: Mendeley Data, V1, doi: 10.17632/85sxdkzvx5.1. Table 1 sets out the inclusion and exclusion criteria to ensure the validity of the analysis

**Table 1.** Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Publications indexed in Scopus (1980-2025).	Documents outside the time range (1980 or 2025).
Studies on RDC and functional textiles (comfort, friction, fit, moisture transport, health, sustainability).	Studies on non-sports socks (medical, orthopedic, fashion).
Articles with technical characterization methodologies (spectroscopy, tribological testing, absorption, liquid transport).	Descriptive or commercial works without scientific evidence.
Peer-reviewed documents in English and Spanish with experimental or bibliometric data.	Grey or non-indexed literature (theses, technical reports, unrefereed memoirs) and without access to verifiable data.

## RESULTS

This section presents the results of the bibliometric review based on the research questions, providing a detailed overview of the trends and patterns identified in the field of study. In relation to the main information on the topic identified in the Bibliometrix collection, table 2 presents the scientific approach to CDR developed with BB, CO, and PAC threads, reviewed from 1990 to the present, as reported in the Scopus multidisciplinary database. The 153 documents were published in 101 sources, including scientific journals, books, and other sources, and demonstrate interdisciplinary interest. With an average of 7 citations per document and a total of 5535 references, the published works have had a significant impact on the academic community. The set of documents shows an annual growth rate of 7 %, demonstrating a growing interest in the area over time. On average, the documents have had an impact for 9 years and are generating both citations and discussions. All of this suggests that the study preferences of CDRs have become an important area of research. Participation among authors includes 400 researchers and 20 % international collaboration, which is a good indicator of the level of cooperation in the scientific community. An average of 3 co-authors per document shows a moderate level of collaboration between researchers. The thematic diversity of the author's keywords, 442 terms and 1157 in Keywords Plus, suggests a variety of approaches and subtopics within the area of study, reinforcing its interdisciplinary richness.

**Table 2.** Main indicators processed in Bibliometrix

Description	Results
<b>Main data information</b>	
Time period	1990:2025
Sources (journals, books, etc.)	101
Documents	153
Annual growth rate %	7,09
Average age of document	8,67
Average number of citations per document	6,974
References	5535
Document content	
Keywords Plus (ID)	1157
Author keywords (DE)	442
Authors	
Authors	400
Authors of single-author documents	21
Collaboration between authors	

Documents by a single author	23
Co-authors per Doc	3,44
International co-authorships %	20,26

Evolution of Publications

Figure 1 shows the evolution of scientific publications on CDR from 2011 to June 2025, revealing significant trends and characteristics.

The development of scientific research on CDR fluctuated from 2010 to 2018, with publications remaining low in the early years. However, since 2013, there has been an increase in publications, albeit with variations; these peaks and troughs may reflect periods of initial exploration, where research advanced experimentally in this field.

Between 2018 and 2020, the average number of publications declined, which may be related to changes in research topics or external factors that affected publication rates. This decline may indicate a phase of research approach review before a new impetus.

In the period 2021-2024, it reached a maximum average number of publications. This peak suggests a research boom, driven by renewed interest in sustainable materials and the application of new technologies in sports textiles. This boom may be driven by a focus on functionality and sustainability in the textile industry, which has gained prominence in recent years.

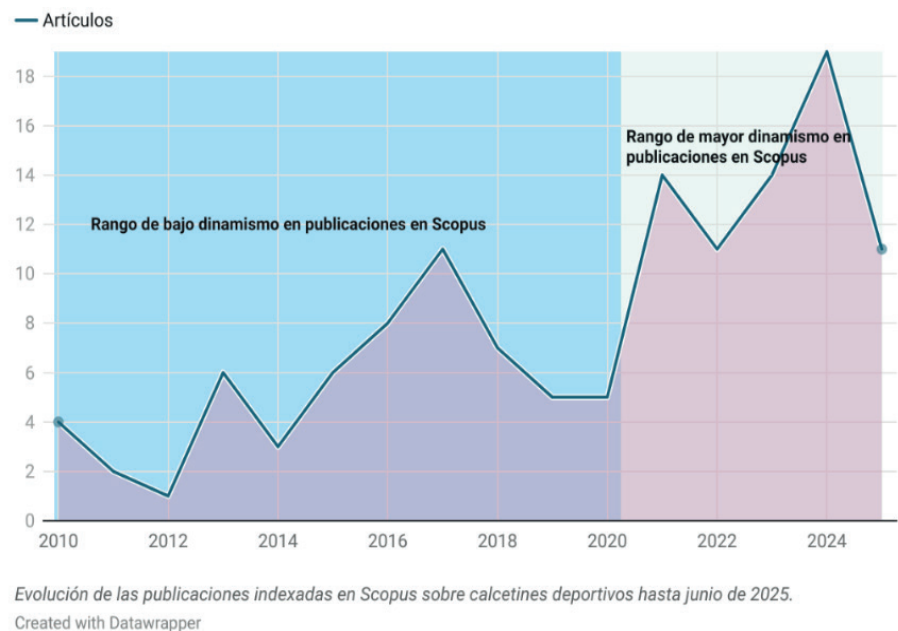


Figure 1. Annual evolution of publications processed in Bibliometrix

Contribution of authors according to Lotka's law

The contributions of researchers to the field of study demonstrate the application of Lotka's law, a theory that describes the distribution of academic productivity.<sup>(13)</sup> Figure 2 presents the analysis of the distribution of authors, showing that 340 authors (85 %) have contributed one article. Researchers in this field are not recurrent, which could reflect that the topic is of specific interest to researchers working in different areas of materials, textiles, or sports applications. Author participation decreases: only 26 authors have published two articles (7 %); 20 have contributed three articles (5 %), and seven have published four articles (2 %). This trend confirms that most research in this area is carried out by individual authors, with a limited number of researchers specializing in continuous, in-depth work on the subject.

Lotka's law model shows a significant decline in the frequency of authors as the number of publications increases. This indicates that the field is mainly analyzed by authors with occasional contributions rather than by recurring specialists. This evolution presents an opportunity for new researchers to position themselves and become leaders, thereby promoting the sustained development of knowledge in BB, CO, and PAC sports socks.

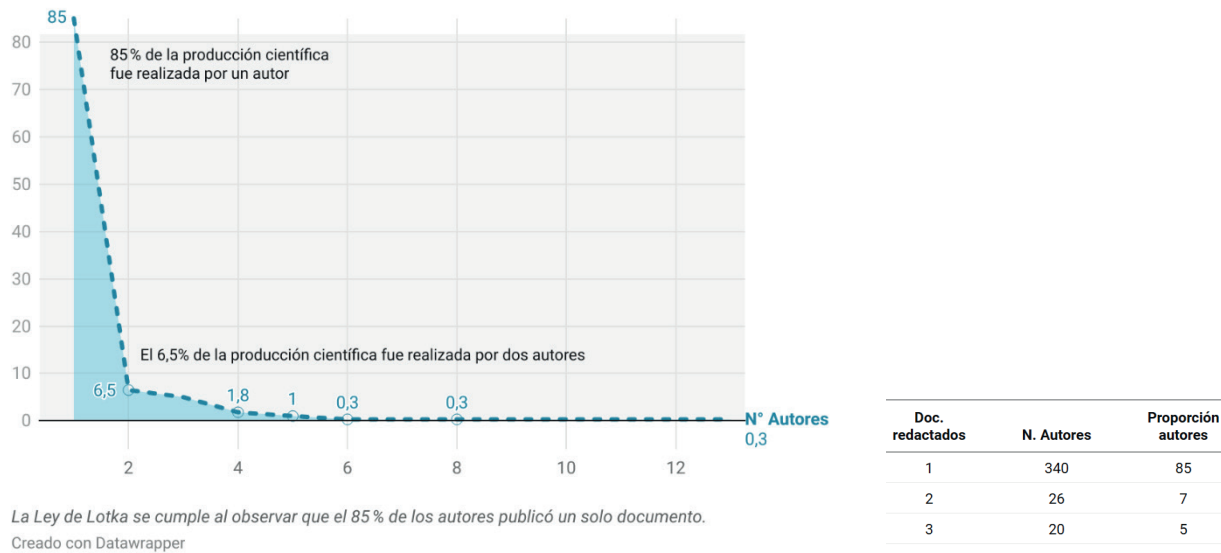


Figure 2. Lotka's Law developed from metadata obtained from Scopus

### Analysis of Author Productivity

Table 3 presents the most influential authors according to bibliometric indicators: h-index, g-index, m-index, total number of citations, and number of publications, also considering the year in which they began their scientific production.

The author Rossi RM is positioned as the primary reference in the field, with an h-index of 6 and 8 publications, obtaining 185 citations since 2010. His academic production and high impact consolidate him as a reference in studies on friction, thermal comfort, and textile design applied to CDR.

He is followed by Derler S and Laing RM, with an h-index of 4, who began publishing in 2010 and 2015, respectively, and have received between 105 and 150 citations, reflecting significant contributions to the area.

Authors such as Abbas A, Anas MS, and Azam Z, who began in 2023, stand out for having achieved an h-index of 3-4 in a short period, which, together with an m-index of 1, suggests rapid visibility and potential for consolidation in the future. In particular, Abbas A, with 13 publications and a h-index of 6, has shown remarkable growth in recent productivity.

Escamilla-Martínez E, Kaplan S, and Lewis R have an h-index of 3, with publications beginning between 2016 and 2018. Although their m-index values are low (0), they maintain a constant participation in the field, contributing relevant and specialized publications.

Table 3. Productivity of the top 10 authors, obtained from Bibliometrix

Author	h-index	g-index	m-index	Total publications	No publications	Year
ROSSI RM	6	8	0	185	8	2010
ABBAS A	4	6	1	47	13	2023
DERLER S	4	4	0	150	4	2010
LAING RM	4	4	0	105	4	2015
ANAS MS	3	5	1	37	5	2023
AZAM Z	3	3	1	26	3	2023
CARRÉ M	3	3	0	17	3	2016
ESCAMILLA-MARTÍNEZ E	3	5	0	32	5	2018
KAPLAN S	3	4	0	20	5	2017
LEWIS R	3	4	0	31	4	2016

### Analysis according to Bradford's Law, main specialized journals in Zone 1

Figure 3 shows the distribution of the leading journals in Zone 1 according to Bradford's Law. This bibliometric model shows that a small number of journals account for most of the relevant publications.

The Revista de Investigación Textil (Textile Research Journal), with 13 publications, is the primary source of information on the subject, specializing in friction, comfort, design, and sustainability in functional textiles. The following journals are: Textiles Industriales (Industrial Textiles) and Revista del Instituto Textil y Procedía



Ingeniería (Journal of the Textile Institute and Engineering Proceedings), both with six publications, focusing on applied research in manufacturing, textile engineering, and physical properties.

They are followed by journals such as Fangzhi Xuebao, Tejido Internacional, Revista de Pruebas y Evaluación e Investigación de Materiales Avanzados, which have between 2 and 4 publications, and which contribute to specialized approaches in mechanical analysis, thermal behavior, material innovation, and functional finishes in sportswear.

This distribution confirms that Zone 1 journals constitute the specialized core of sports textiles research and are key to positioning new research, enhancing scientific visibility, and guiding the dissemination of knowledge in sustainable functional textiles.

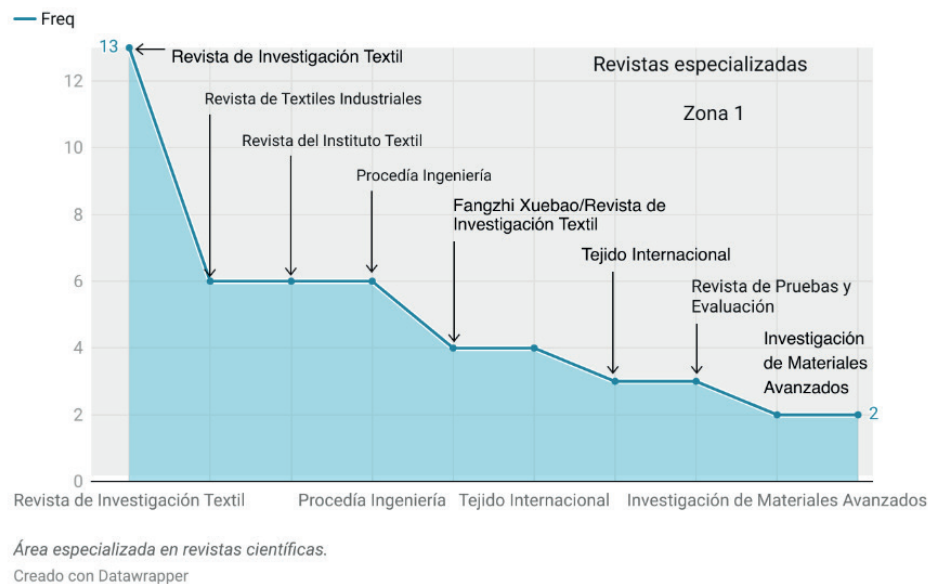


Figure 3. Main specialized journals in Zone 1 according to Bradford's Law

Productivity of the top 10 journals

Table 4 shows the Revista de Investigación Textil (Textile Research Journal), which ranks as the primary academic source in the study of functional socks, with the highest bibliometric impact, including an h-index of 8266 citations, and 13 publications since 2010. Its m-index of 1 confirms continued productivity over time, especially in topics related to comfort, friction, and textile sustainability.

Table 4. Productivity of the top 10 journals related to socks					
Source	h-index	m-index	Total citations	Non-publications	Year
Textile Research Journal	8	1	266	13	2001
Procedia Engineering	5	0	41	6	2015
Journal of Engineering Fibers and Fabrics	3	0	26	3	2019
Industrial Textiles Magazine	3	1	19	6	2002
Textile Institute Magazine	3	1	38	6	2021
Advanced Materials Research	2	0	5	2	2011
Foot	2	0	24	2	1996
International Journal of Environmental Research and Public Health	2	0	13	2	2019
Tribology Letters	2	0	17	2	2015
Applied Materials and Interfaces ACS	1	0	6	1	2002

The journal Procedía Ingeniería ranks with an h-index of 5, 41 citations, and six publications, demonstrating an applied approach to textile engineering processes. However, its m-index of 0 indicates low continuity in the subject area.

Other journals with minimal impact, such as Revista de Fibras y Telas de Ingeniería, Revista de Textiles Industriales, and Revista del Instituto Textil, have an h-index of 3 and a production of between 3 and 6 articles, with a range of 19 to 38 citations, which shows moderate but constant interest in the area of textile materials

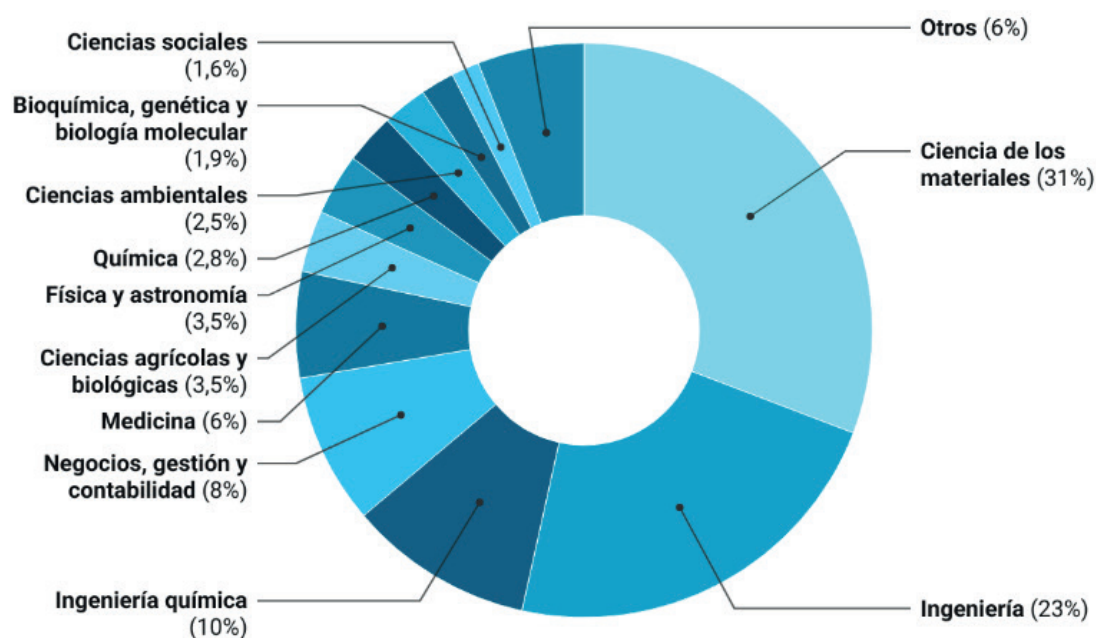
for sports performance.

Journals such as *Investigación de Materiales Avanzados*, *Pie*, *Revista Internacional de Investigación Ambiental y Salud Pública*, and *Cartas de Tribología* participate at a lower level, although still relevant, all with an h-index of 2 and two publications each. These contribute specific approaches from biomechanics, tribology, and environmental assessment.

Finally, the ACS journal *Applied Materials & Interfaces*, with an h-index of 1 and a single publication, reflects emerging interest in functional textiles among high-impact materials science journals.

### Analysis of the Main Areas of Knowledge

Figure 4 presents the analysis of research on CDR, carried out in a multidisciplinary framework led by Materials Science (31 %) and focused on the physical and functional properties of textiles. This is followed by Engineering (23 %), which contributes knowledge on the design and manufacture of functional socks; in third place is Chemical Engineering (10 %), which contributes to the design, manufacture, and treatment of technical fibers. Areas such as Business (8 %) and Medicine (6 %) offer perspectives on sustainability, the market, and user health. Other complementary disciplines, such as Physics, Biology, Chemistry, and Environmental Sciences, address specific aspects ranging from structural behavior to environmental impact. Finally, the Social Sciences (1,6 %) reflect an interest in the user experience and sociocultural acceptance of functional sports textiles.



*Áreas del conocimiento desde las cuales se desarrolla la investigación sobre calcetines deportivos para running.*  
Creado con Datawrapper

Figure 4. Areas of knowledge addressed by sports running socks

### Cluster Analysis and Research Patterns

Figure 5 shows the semantic map created with VOSviewer, which provides an overview of the main thematic areas and the relationships among frequently used terms in research on CDRs conducted with BB, CO, and PAC. The co-occurrence map identifies five thematic clusters of CDRs.

The green cluster: shows the topic of biomechanics and user health, addressing terms such as fit, foot temperature, and injury prevention.

The blue cluster, which forms the map's densest core, addresses terms such as friction, tribology, and materials, highlighting fabric-skin interactions and moisture absorption.

The red cluster is related to topics in the textile industry, thermal comfort, sports socks, and knitted fabrics.

The yellow cluster studies topics such as design, fibers, and structures, addressing properties such as compression and elasticity.

The central cluster (multicolored intersection) serves as a connecting node for all clusters related to the terms "socks" and "comfort."

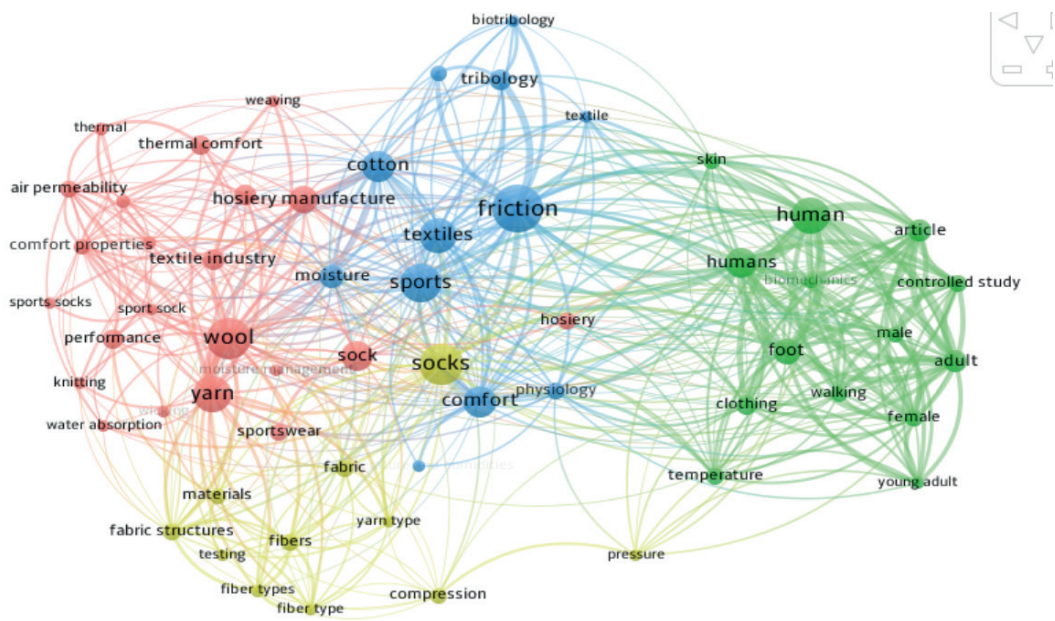


Figure 5. Semantic map generated by VOSviewer

Thematic Map

Figure 6 shows the thematic map from the bibliometric analysis, which classifies CDR research terms by density and centrality. This representation allows the status and function of the different research topics to be identified.

The driving themes (high centrality and density), such as human, foot, and humans, indicate a strong focus on biomechanics and user health.

Basic themes, such as friction, sports, and textiles, are essential but still under development, related to the functional behavior of materials.

Emerging topics, such as antimicrobial property, design, and product development, represent underdeveloped areas that could be losing relevance or presenting new lines with innovative potential. Finally, niche topics, such as knitting technologies and the finite element method, demonstrate advanced technical approaches with internal development, although less closely connected to the general thematic core.

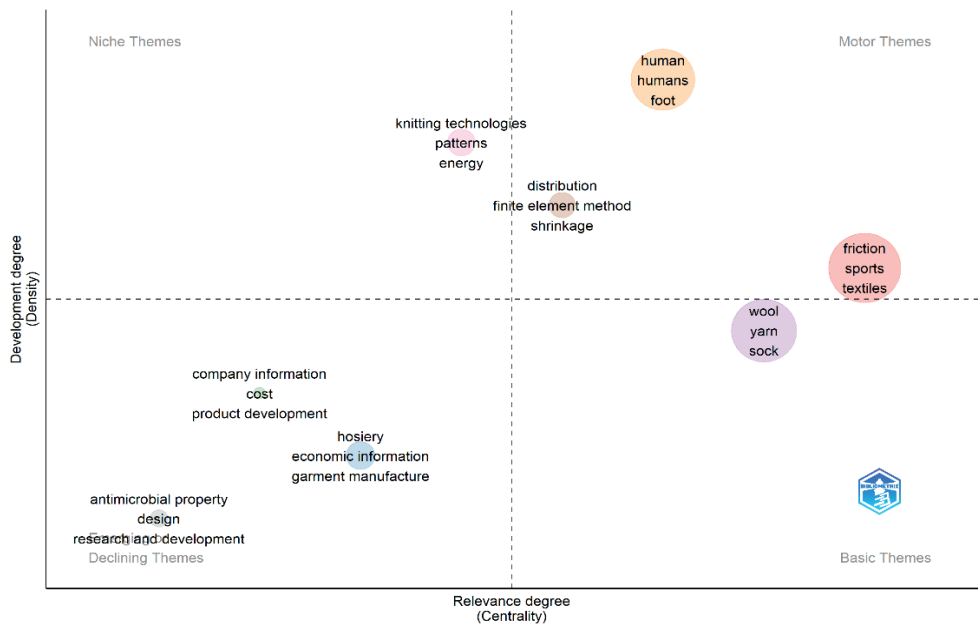


Figure 6. Structural thematic map (Direct map from Bibliometrix)

Spectroscopy of the year of the cited reference

Spectroscopy reveals the citation trend in CDR research documents, focusing on topics such as friction,



blister prevention, thermal properties, and comfort in sports footwear. The contributions of each of the papers presented in figure 7 are analyzed below.

According to <sup>(14)</sup>, the fabric structures were evaluated for blister prevention in running socks. Six models of cotton socks with different textures were assessed. Double-knit terry and plain knit fabrics performed better and provided greater foot protection.<sup>(15)</sup>

According to <sup>(16)</sup> Tribology of human skin and mechanical equivalents of skin in contact with textiles. This research examined the friction between the skin and a reference textile, finding that the coefficients vary with skin hydration and are due to a combination of adhesion and hysteresis. The polyurethane-coated polyamide fabric revealed the best behavior, similar to dry skin. They conclude that the use of skin models and testing methods can optimize the design of textiles appropriate for sports and medical applications.

For, <sup>(6)</sup> Effects of sock type on foot skin temperature and thermal demand during exercise. This research compared standard and ergonomic socks during exercise and found no significant physiological differences. However, the ergonomic sock was perceived as cooler and more cushioned, indicating that subjective perception may influence physiological data when choosing socks for prolonged use.

According to <sup>(17)</sup>, "Liquid transport in textile structures." This study evaluates liquid transport in cotton and polyester fabrics, showing that moisture absorption and retention depend on capillary action, wetting, and the porous structure of the material, influenced by the surface properties of the fibers and the geometry of the pores, evidencing the behavior of moisture in socks.

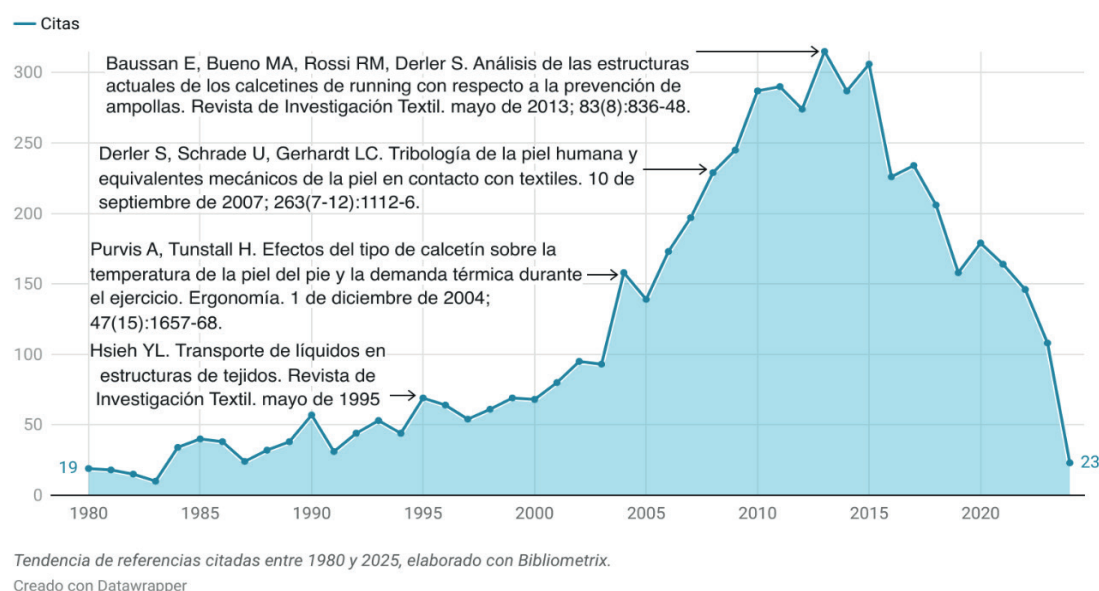


Figure 7. Spectroscopy from the referenced year

## DISCUSSION

The bibliometric analysis allowed us to establish in detail the status and evolution of the scientific production of CDRs made with BB, CO, and PAC threads. The general information showed sustained annual growth of 7 %, demonstrating the scientific community's interest in this line of research. Likewise, Lotka's Law showed that most authors have contributed only one publication, suggesting that this is still an expanding field with few established specialists.

Publications between 1990 and 2024 show an upward trend with fluctuations. Between 2011 and 2019, progressive increases were observed; the period 2021-2023 recorded significant growth, probably driven by the demand for functional and sustainable textiles. This trend aligns with global research on ecological fibers and the development of high-performance technical garments.

Regarding authors, the study identified<sup>(14)</sup> as the most cited researcher, with a continuous track record since 2010. Authors such as <sup>(15)</sup> have had a significant impact, while new players such as <sup>(18)</sup> show recent and promising development.

Regarding leading journals, the Textile Research Journal strengthened its position as the primary dissemination channel, with 13 articles and the highest h-index, followed by Procedia Engineering and the Journal of Industrial Textiles. This concentration of publications in specialized journals confirms the centrality of the topic in the field of functional and high-performance textiles. There is also diversification towards multidisciplinary journals that investigate health, design, and engineering.

The areas of knowledge show a multidisciplinary approach. Materials Science accounts for 31 % of production,

followed by Engineering (23 %) and Chemical Engineering (10 %), indicating that the study of socks extends beyond textile design to encompass fiber modification processes, physical-mechanical properties, and advanced manufacturing technologies. Areas such as Medicine, Environmental Sciences, and Social Sciences, with a lesser presence, provide a comprehensive view that encompasses user health, environmental impact, and perception of comfort.

Semantic development, as revealed by cluster analysis, yielded five thematic clusters. Friction, moisture, compression, biomechanics, and functional fabric design are the axes that structure the semantic network. The term “comfort” appears as a central node, which shows that, regardless of the technical or physiological approach, the common goal of this line of research is to optimize the user experience in sports conditions.

In the thematic map, driving themes such as human, foot, and humans were identified, which show a high level of development and centrality with respect to foot biomechanics and user health. Basic themes such as friction and textiles underpin the area but still require further exploration. Themes such as design, antimicrobial properties, and functionality were classified as emerging, suggesting new lines of research. On the other hand, areas such as knitting technologies and finite element method appear as niche topics, developed but still peripheral to the central axis of knowledge.

Spectroscopy from the reference year cited allowed for analysis of historical developments in the field, emphasizing advances such as the studies by Herring<sup>(5)</sup> on friction and blister formation, and the work of <sup>(14)</sup>, which established a shift toward more technical and physiological approaches. The period 2010-2017 represents the phase of most significant impact, followed by a decline, possibly due to thematic diversification into new areas such as sustainability or smart textiles.

## CONCLUSIONS

The bibliometric study shows sustained development in research on sports socks (CDR) made with BB, CO, and PAC. The subject has evolved from a technical focus on friction and fit to a broader approach that incorporates thermal comfort, user health, and material sustainability, thereby consolidating the orientation toward functional textiles for sports performance.

There is a diversification of authors and approaches, with established and emerging researchers driving new lines in functional design and innovative materials. Publications are concentrated in materials and textiles journals but are increasingly moving into transdisciplinary fields such as applied engineering, sports medicine, and ergonomics, reflecting the field's expansion.

Semantic and thematic analyses highlight friction, comfort, moisture, biomechanics, and fit as established themes, along with emerging lines in product design and antimicrobial properties, which have high development potential. Likewise, initial studies based on spectroscopy laid the foundations for current research by relating skin and textiles in friction, blister prevention, and thermal regulation.

The sports socks of the future will need to integrate optimized textile structures, sustainable materials, and emerging technologies that reduce friction, prevent injuries, and enhance performance. Their development is geared toward dual purposes: protecting athletes' health and addressing environmental sustainability challenges in the textile industry.

## BIBLIOGRAPHIC REFERENCES

1. Younes B. Textronics: a review of their technological aspects and applications. *J Text Inst.* 2024;115(9):1509-25. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85165573525&doi=10.1080%2F00405000.2023.2236320&partnerID=40&md5=3e764b670066499a055668fb1c7696d6>
2. Umair M, Nadeem M, Jamshaid H. A Prospective Comparison of Materials and Structures for Sports Graduated Compression Socks. *J Test Eval.* 2024;52(2):1-18. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85182877267&doi=10.1520%2FJTE20230196&partnerID=40&md5=6b7518a4cd618d43f8d7945e66438b1c>
3. Profile of X-bionic: A high-end sportswear brand. *Text Outlook Int.* 2016;2016(180):138-49. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84974806602&partnerID=40&md5=60d62d591b307d2af69246aa7a5d99be>
4. Torres-Salinas D, Orduña-Malea E, -Vázquez D, Arroyo-Machado W. Fundamentos de Bibliometría Narrativa 2023. Univ Granada. 2024;1-24. <https://sfdora.org/>
5. Herring KM RDJ. Friction blisters and sock fiber composition. A double-blind study. A double-blind study *J Am Pod Med Assoc.* 1990;
6. Purvis AJ, Tunstall H. Effects of sock type on foot skin temperature and thermal demand during exercise. *Ergonomics.* 2004;47(15):1657-68. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-9444255248&doi=10.1080%2F0014013903100017333>

0.1080%2F00140130412331290880&partnerID=40&md5=be67c3796a106ab6342193f36d4f9e9a

7. Arafa Badr A. Anti-microbial and durability characteristics of socks made of cotton and regenerated cellulosic fibers. *Alexandria Eng J.* 2018;57(4):3367-73. <https://doi.org/10.1016/j.aej.2017.11.015>

8. Campina, Alejandro. Lorca, Antonio. de Illas Heras A. Indagación, modelización y pensamiento computacional: Un análisis bibliométrico con el uso de Bibliometrix a través de Biblioshiny. 2024. <https://www.redalyc.org/journal/920/92075647006/html/>

9. Temuco BU. Guías temáticas: Bibliometrix: Instalación de R Studio.; <https://uct.libguides.com/c.php?g=1429726&p=10609992>

10. VOSviewer. VOSviewer :: Download. 2023. <https://www.vosviewer.com/download>

11. Bibliometrix-Home. 2024. 2024. Bibliometrix. <https://www.bibliometrix.org/home/index.php>

12. VOSviewer. VOSviewer - Visualizing scientific landscape. 2023. <https://www.vosviewer.com/>

13. URBIZAGASTEGUI R. La ley de Lotka y la literatura de bibliometría. *Investig Bibl Arch Bibl e Inf.* 1999 Jul 1;13(27). <http://rev-ib.unam.mx/ib/index.php/ib/article/view/3913>

14. Baussan E, Bueno M, Rossi R, Derler S. Analysis of current running sock structures with regard to blister prevention. *Text Res J.* 2013;83(8):836-48. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84876565428&doi=10.1177%2F0040517512461698&partnerID=40&md5=7a3a6f475fe08b56ec15c43c077f7075>

15. Baussan E, Bueno MA, Rossi RM, Derler S. Analysis of current running sock structures with regard to blister prevention. *Text Res J.* 2012 Oct 26;83(8):836-48. <https://doi.org/10.1177/0040517512461698>

16. Derler S, Schrade U, Gerhardt LC. Tribology of human skin and mechanical skin equivalents in contact with textiles. *Wear.* 2007;263(7-12 SPEC. ISS.):1112-6.

17. Hsieh Y lo. in *Fabric Structures.* 2015;299-307.

18. Anas MS, Abbas A, Awais H, Sarwar ME, Hassan TU, Abbas H. A study on the effect of material type, structure tightness and finishing process on the physical and thermo-physiological properties of sandwich terry socks for winter wear. *J Eng Fiber Fabr.* 2023;18. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85147731811&doi=10.1177%2F15589250231153398&partnerID=40&md5=2e4ef1581aa39a34c6d065a00c6a60ff>

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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