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Mapping the Scientific Landscape: A Bibliometric Analysis of Exercise and Skin Health Research (2005–2025)

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Abstrak:
Pendahuluan: Aktivitas fisik telah lama dikenal sebagai faktor penting dalam menjaga kesehatan secara menyeluruh, termasuk fungsi kardiovaskular, metabolik, dan imun. Namun, peran olahraga dalam menjaga dan meningkatkan kesehatan kulit khususnya dalam konteks dermatologi dan estetika masih relatif jarang dibahas dalam literatur ilmiah. Pendekatan bibliometrik mengidentifikasi tren dan kesenjangan penelitian, yang memandu penelitian di masa mendatang tentang olahraga dan kesehatan kulit. Penelitian ini bertujuan untuk memetakan lanskap penelitian global terkait dampak olahraga terhadap kesehatan kulit melalui pendekatan bibliometrik. **Metode:** Data dikumpulkan dari basis data Scopus dengan menggunakan kombinasi kata kunci seperti “exercise,” “training,” “sports medicine,” “skin health,” dan “aesthetics.” Sebanyak 43 artikel yang relevan dan diterbitkan dalam rentang tahun 2005 hingga 2025 berhasil diidentifikasi. Analisis dilakukan menggunakan Microsoft Excel untuk pengolahan data awal, VOSviewer untuk visualisasi jejaring kata kunci, serta R Studio dengan paket Biblioshiny untuk analisis bibliometrik lanjutan. **Hasil:** Hasil menunjukkan peningkatan jumlah publikasi yang signifikan sejak tahun 2018, dengan puncak pada tahun 2023 dan 2024. Amerika Serikat dan Inggris menjadi negara dengan kontribusi publikasi tertinggi, diikuti oleh Kanada, India, dan Turki. Mayoritas artikel dipublikasikan dalam jurnal yang berfokus pada bedah estetika dan rehabilitasi medis. Analisis kata kunci menyoroti tema-tema utama seperti “aesthetic surgery,” “training,” dan “skin regeneration”. Kesimpulan: **Kesimpulan:** Topik olahraga dan kesehatan kulit menunjukkan perkembangan yang positif dan mendapat perhatian lintas disiplin, terutama dari bidang kedokteran olahraga, dermatologi, dan estetika. Studi ini memberikan dasar awal untuk eksplorasi penelitian integratif di masa mendatang.
Kata kunci: Aktivitas fisik ; Analisis bibliometrik; Kesehatan kulit ; Olahraga

Abstract:
Introduction: Physical activity has long been recognized as a key factor in promoting overall health, including cardiovascular, metabolic, and immune function. However, its role in skin health particularly in dermatological and aesthetic contexts remains underexplored in scientific literature. The bibliometric approach identifies research trends and gaps, guiding future studies on exercise and skin health. This study aims to map the global research landscape related to the impact of exercise on skin health using a bibliometric approach. **Methods**: Data were retrieved from the Scopus database using a combination of keywords such as “exercise,” “training,” “sports medicine,” “skin health,” and “aesthetics.” A total of 43 relevant articles published between 2005 and 2025 were identified. The analysis utilized Microsoft Excel for initial data processing, VOSviewer for keyword network visualization, and R Studio with Biblioshiny for advanced bibliometric mapping. **Results:** The findings show a notable increase in publication volume starting in 2018, peaking in 2023–2024. The United States and the United Kingdom led in research output, followed by Canada, India, and Turkey. Most studies were published in journals focused on aesthetic surgery and rehabilitative medicine. Keyword analysis revealed dominant themes such as “aesthetic surgery,” “training,” and “skin regeneration.” **Conclusion:** Research on exercise and skin health is gaining momentum, supported by interdisciplinary interest from the fields of sports science, dermatology, and aesthetic medicine. Conclusion: The study highlights current trends, identifies research gaps, and provides a foundation for future integrative research aimed at enhancing both health and appearance through physical activity.
Keywords: *Bibliometric analysis; Exercise; Physical activity; Skin health*

1. Introduction

Physical activity has long been recognized as a foundational pillar in maintaining overall health and well-being. According to the World Health Organization, physical activity encompasses any bodily movement produced by skeletal muscles that require energy expenditure (1), including activities performed during leisure time, commuting, work, and household tasks. Among the various forms of physical activity, exercise is considered one of the most common and structured modalities (2). Exercise refers to planned and systematic physical activity aimed at improving or maintaining physical fitness. Beyond its well-known benefits for physical performance, exercise has been scientifically proven to exert wide-ranging physiological advantages, from enhancing cardiovascular health to strengthening the immune system (3).

In addition to its impact on internal organs, exercise also plays a significant role in the health of the body's largest external organ (4). The skin serves as a vital barrier, contributing to internal homeostasis through protective functions, temperature regulation, and prevention of fluid loss. In recent years, a growing body of scientific literature has highlighted the positive contributions of exercise to skin health. These benefits are mediated through mechanisms such as increased blood flow, elevated skin temperature, and improved hydration (5). Physical activity stimulates mitochondrial biogenesis in skin fibroblasts, promoting skin regeneration and strengthening the skin’s barrier function, leading to increased resilience and protection. Enhanced circulation during physical activity allows for more efficient delivery of oxygen and nutrients to skin tissues, facilitating optimal cell regeneration. Moreover, exercise stimulates hormonal secretion that supports mitochondrial biosynthesis and the repair of skin structure, including an increase in collagen content in the dermal layer (5,6).

Despite these promising insights, the relationship between exercise and skin health remains relatively underexplored in the scientific literature compared to other health domains, such as cardiometabolic diseases or mental health. Numerous studies have established that regular physical activity significantly reduces the risk of chronic conditions such as diabetes and hypertension, while also improving obesity-related outcomes. Additionally, moderate-intensity exercise has been found to provide mental health benefits comparable to pharmacological treatments (7). However, research examining the potential of exercise to slow skin aging or repair environmentally or age-induced skin damage is still lacking. Given the increasing public interest in skin care and appearance, this topic has become increasingly relevant from both medical and aesthetic perspectives.

To address this, a bibliometric approach offers a powerful tool for identifying trends, research gaps, and mapping the evolving body of scientific literature. As previously defined, bibliometric analysis is a quantitative method used to systematically evaluate large volumes of academic publications (8). Utilizing tools such as VOSviewer, Bibliometrics, and CiteSpace, researchers can assess how interconnected topics like exercise and skin health have been explored, identify leading authors in the field, and track the evolution of keywords and research foci over time (9,10). Thus, bibliometric analysis not only serves as an evaluative tool but also as a scientific navigation strategy, offering insights into understudied topics such as the physiological effects of exercise on skin structure and function (11). Through this approach, the present study aims to provide a comprehensive scientific map of the contributions of exercise to skin health, while identifying emerging trends in this interdisciplinary field. The findings are expected to lay the groundwork for future interdisciplinary research, particularly within the emerging field of sports dermatology.

2. Method

This study employed a bibliometric analysis approach, a quantitative method used to identify publication patterns, author collaborations, institutional affiliations, and emerging research themes (12). The main objective of using this method is to gain a comprehensive understanding of the global research landscape concerning the relationship between physical activity and skin health. Bibliometric analysis enables researchers to systematically assess the development, trends, and gaps in the existing body of literature (13).

2.1 Data Collection

The data source selected for this research is the Scopus database. Scopus was chosen due to its wide multidisciplinary coverage and its indexing of high-quality, peer-reviewed scientific publications. Scopus was selected for this study because it offers extensive global coverage and consistent citation indexing, which supports accurate bibliometric analysis. Its structured metadata and integration with bibliometric software make it a reliable source for assessing research performance across disciplines (14). To retrieve relevant literature, a search strategy was designed using a combination of keywords: "(exercise OR workout OR training OR sports medicine) AND (skincare OR aesthetics OR skin health)". These keywords were carefully chosen to encompass a broad spectrum of terms related to physical activity as well as skincare and health, covering both clinical and aesthetic contexts (15).

2.2 Inclusion and Exclusion Criteria

Inclusion criteria for article selection were clearly defined to ensure the relevance and quality of the documents analyzed. The study includes articles that were: (1) published between 2005 and 2025, (2) written in English, and (3) categorized under specific subject areas, namely Medicine, Neuroscience, Biochemistry, Genetics and Molecular Biology, Nursing, Immunology and Microbiology, and Pharmacology, Toxicology and Pharmaceutics. These subject categories were chosen to focus the analysis on literature that contributes to medical and scientific discussions surrounding the research topic. The bibliographic data collected from each document included the names of the authors, year of publication, article titles, institutional affiliations, countries of origin, source journals, and keywords.

2.3 Data analysis

All data were derived from the article metadata provided by the Scopus platform. The article screening and selection process is visually represented in **Figure 1**, which outlines the step-by-step flow from the initial keyword search to the final inclusion of articles deemed eligible for analysis (12). The data analysis process used three main software that can be accessed for free, namely Microsoft Excel, VOSviewer, and R Studio with the Biblioshiny package. Excel was used for initial data processing and table preparation, and VOSviewer was used to visualize the relationship network between keywords using co-occurrence analysis. R Studio is used for advanced bibliometric analysis and preparation of more complex graphs for analysis of annual research developments, authors, countries, affiliations, and sources with the highest contributions.

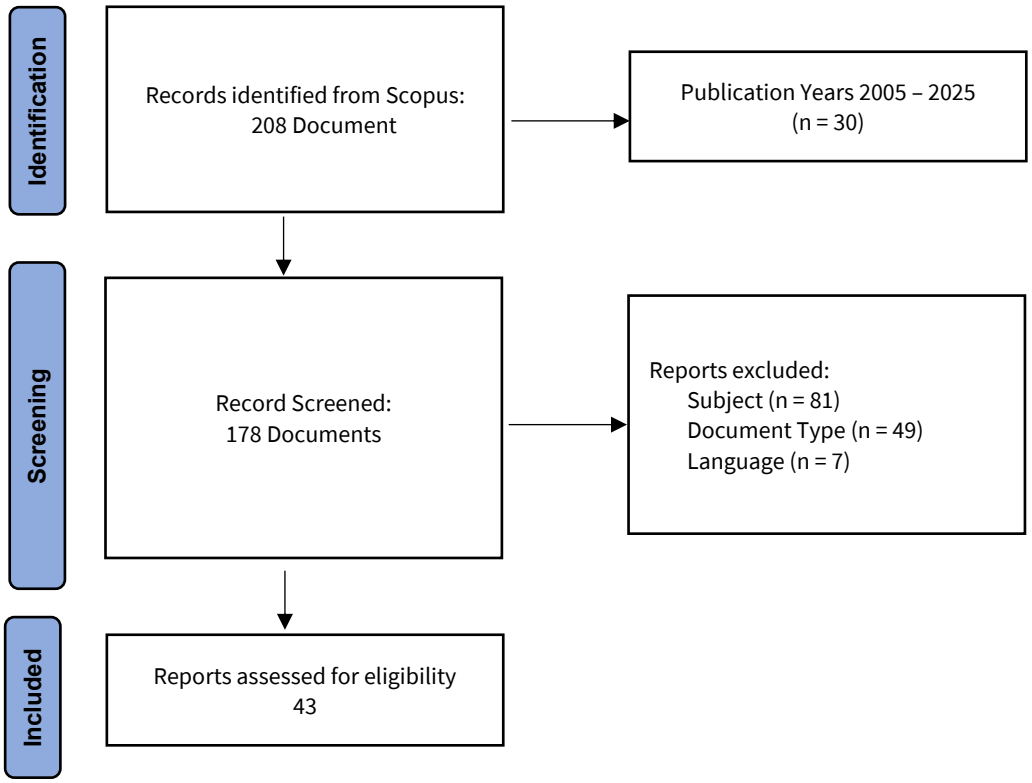

Figure 1. Document screening flowchart

3. Results

3.1 Annual Publication

Based on the screening process conducted using the predetermined inclusion criteria, a total of 43 relevant articles were identified that focus on the benefits of exercise for skin health. These articles were published between 2005 and 2025, reflecting a growing scientific interest in the intersection between physical activity and dermatological or aesthetic aspects of the skin. **Figure 2** explains annual publications during the initial years, from 2005 to 2017 the number of publications remained relatively low and stable, ranging from one to two articles per year. A gradual increase began in 2018 and continued through 2022. The most significant rise occurred in 2023 and 2024, with each year recording the highest number of publications at five articles per year.

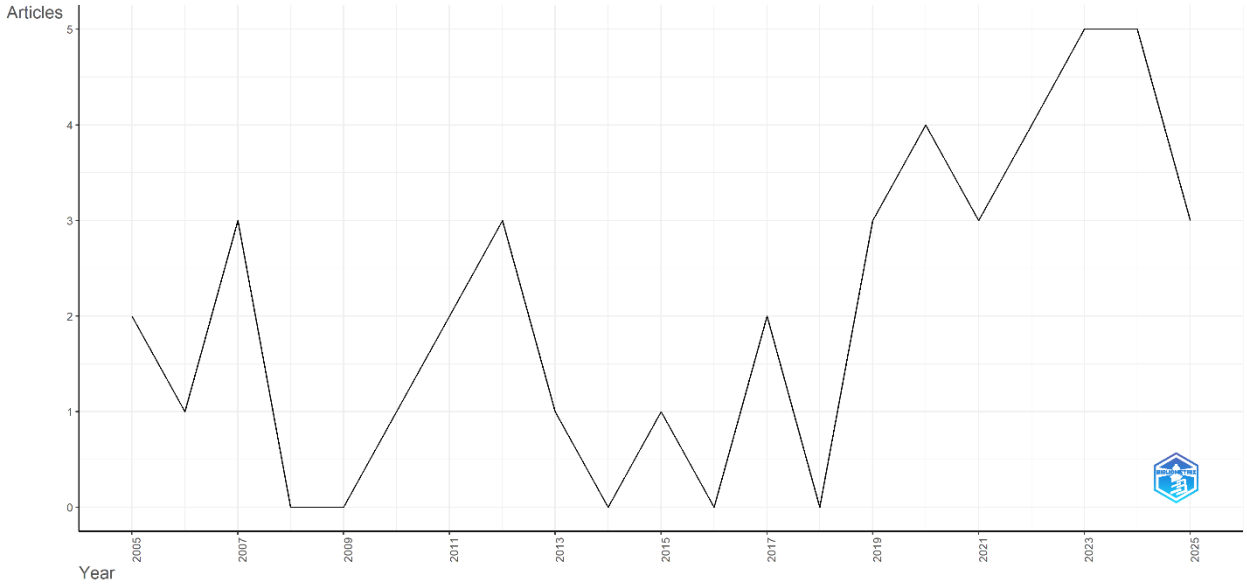

Figure 2. The trend of publication growth over the years

3.2 Most Relevant Author

An analysis of author contributions revealed a total of 152 individual authors involved in the selected articles. Among them, only two authors, Janis JE, and Zins JE, were found to have published more than one article, each contributing to two publications as shown in **Figure 3**. The remaining 150 authors contributed to only one publication each. This finding suggests that, although the topic has attracted a wide range of contributors, it has not yet formed a concentrated or established research community.

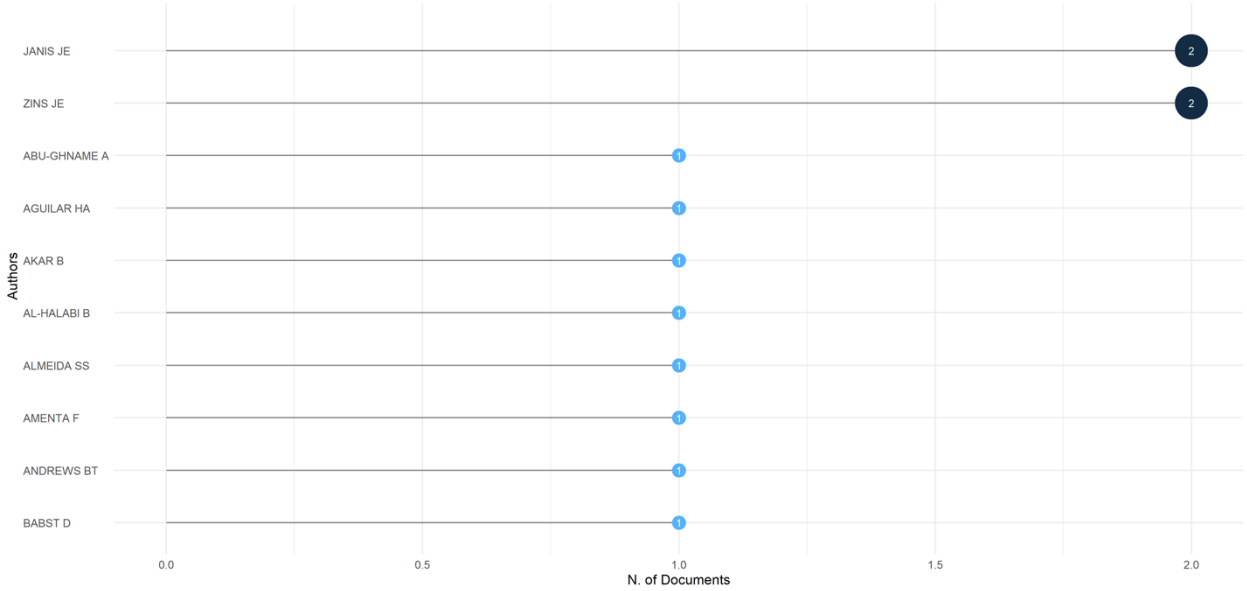

Figure 3. Top ten authors with the highest number of publications

3.3 Most Relevant Country

The reviewed publications originated from 22 different countries, indicating the global scope of interest in the topic of exercise and skin health. The United States and the United Kingdom led with the highest number of publications, each contributing 15 articles, highlighting the dominance of Western countries in developing this research field. Canada ranked third with four publications, followed by India and Turkey with three publications each, and Italy with two, and other countries contributed one publication each as shown in **Figure 4**.

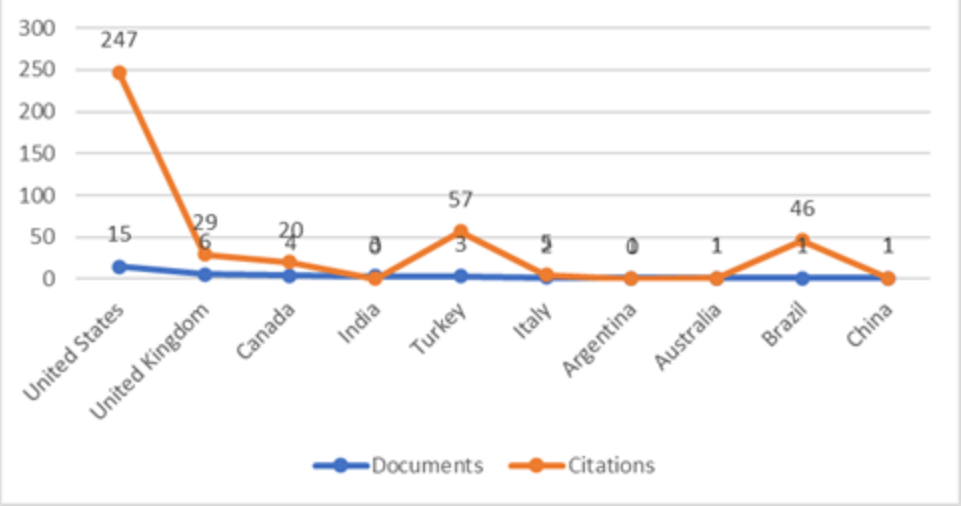

Figure 4. Top countries with the highest number of publications

3.4 Most Relevant Affiliations

A total of 68 affiliations were identified as contributors to the articles analyzed. Among them, Baylor College of Medicine emerged as the most prolific institution with seven publications as shown in **Figure 5**. It was followed by University Hospital Basel with six publications. Five other institutions contributed five publications each, seven institutions contributed four, and four institutions published three articles. An additional nine institutions each contributed two articles.

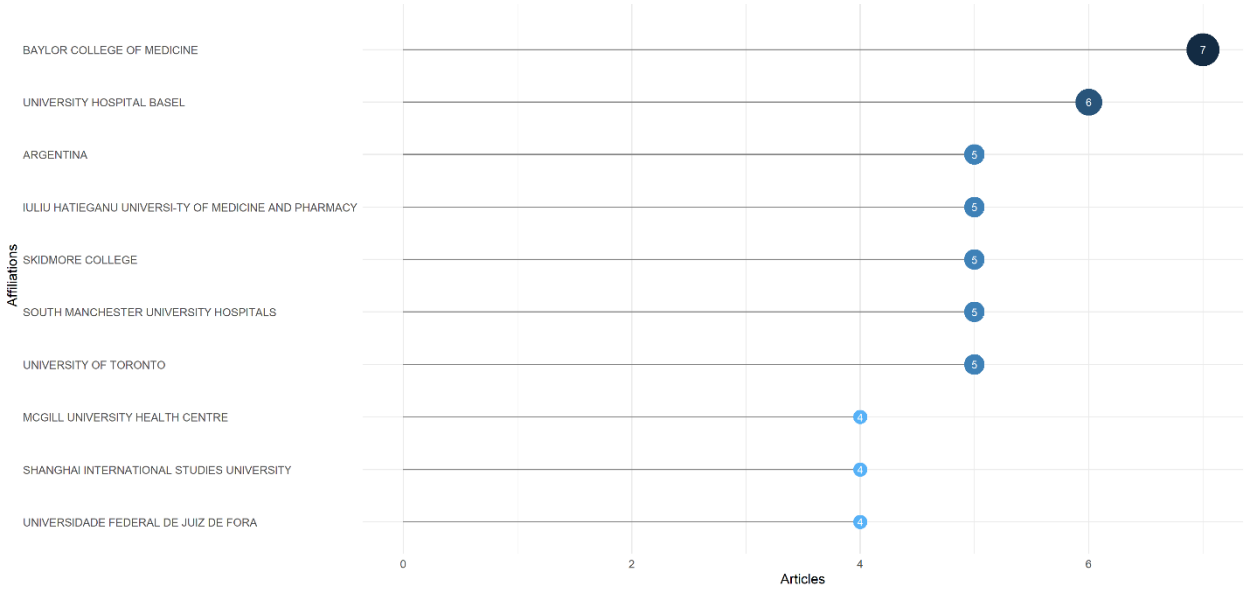

Figure 5. Top affiliation with the highest number of publications

3.5 Most Relevant Source

The articles were published across various scientific sources, most of which focus on aesthetic medicine, plastic surgery, and medical rehabilitation. The two leading journals in this area were the Aesthetic Surgery Journal and Plastic and Reconstructive Surgery Global Open, each publishing five articles. These were followed by the

Journal of Plastic, Reconstructive and Aesthetic Surgery, and Plastic and Reconstructive Surgery, with four publications each. These journals served as key platforms for researchers to disseminate findings on the interaction between physical activity and skin health or care. **Figure 6** shows the ten most frequently used sources in this field, emphasizing the prominence of this topic in the aesthetic and surgical medicine communities. This trend further highlights that many of the studies on the benefits of exercise for the skin are framed within medical and aesthetic contexts, particularly in areas such as wound healing, skin elasticity, and post-surgical cosmetic outcomes.

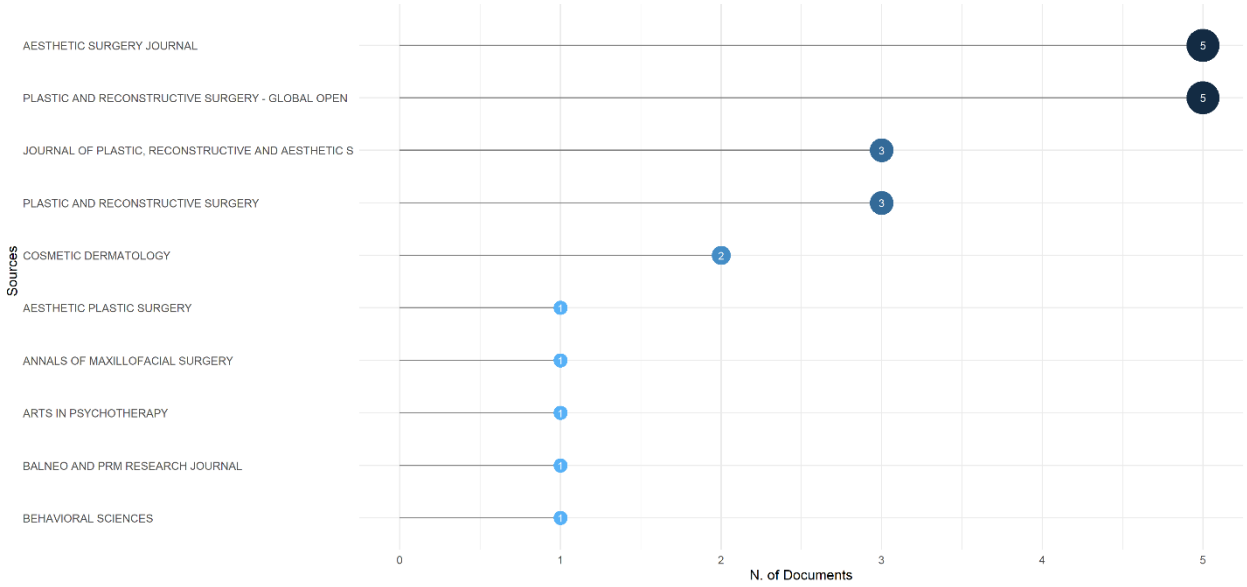

Figure 6. Top sources with the highest number of publications

3.6 Most Relevant Author Keyword

Keyword analysis of the 43 articles revealed a total of 104 unique keywords. Among these, 55 keywords were interconnected and formed a network visualized using VOSviewer, as presented in **Figure 7**. The keyword “aesthetic” appeared as a central node in the network, indicating that the aesthetic dimension is a primary focus of research linking exercise and skin. Other frequently occurring keywords included “aesthetic surgery” (4 occurrences), “aesthetic” (3), and “cosmetic surgery” and “training” (2 each). The remaining keywords appeared only once, reflecting the wide scope and diversity of research topics, which range from aesthetic surgery to exercise training and physical therapy. The keywords identified indicate the achievement of this research, as evidenced by the alignment between the findings and the objectives of this study.

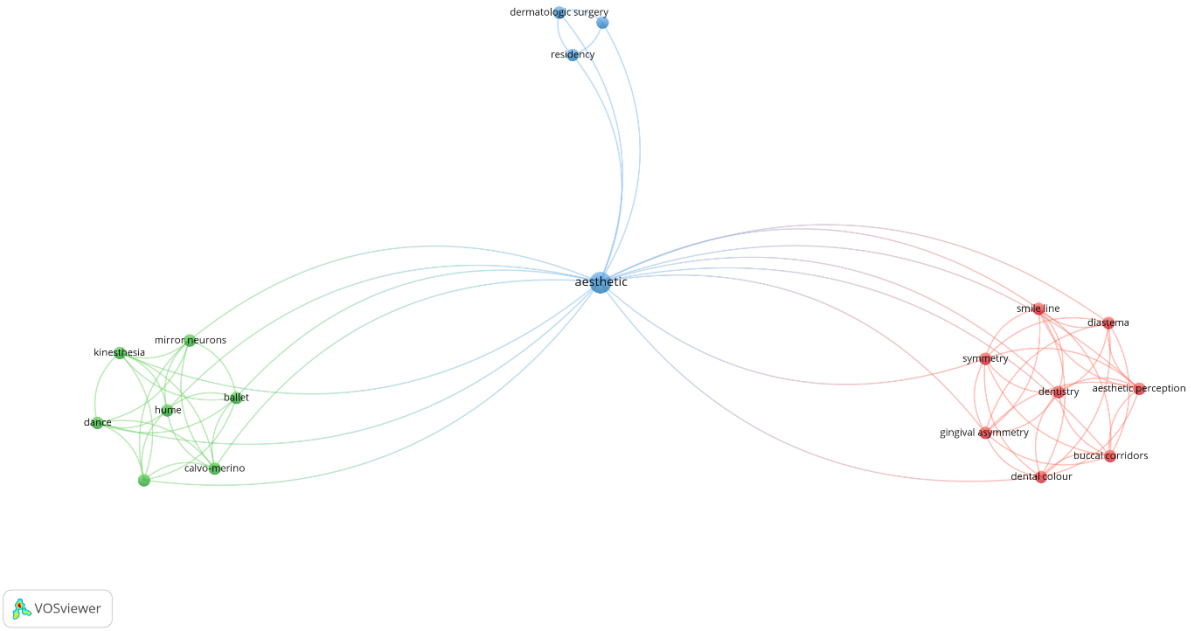

Figure 7. Keyword network used by authors

4. Discussion

Publications on the topic of exercise and skin health have shown a steady increase, particularly since 2018. Between 2005 and 2017, the number of studies remained relatively constant, suggesting that the link between physical activity and skin health had not yet gained significant attention in academic research. The rising trend after 2018 reflects a growing recognition of the benefits of exercise not only for general well-being but also for skin appearance and preventive dermatology. Although many authors contributed only once, the diversity of contributors including medical professionals, academics, and practitioners in sports medicine and aesthetic surgery indicates interdisciplinary interest. Countries such as the United States, United Kingdom, and Canada lead in publication output, likely due to strong research infrastructures, a culture that values health and aesthetics, and a well-developed beauty and wellness industry. Meanwhile, increasing contributions from countries like India and Turkey reflect expanding access to dermatological and aesthetic care, alongside a growing public interest in active and health-conscious lifestyles.

Keyword analysis highlights central themes like blood circulation, skin regeneration, and medical aesthetics. These terms point to a clear link between physical activity and skin health, beyond cosmetic interest. The presence of terms related to aesthetic education and procedures suggests a growing overlap between clinical practice and research. This evolution indicates that the field is becoming more interdisciplinary, combining health, aesthetics, and wellness. The global distribution of studies also suggests increasing international relevance and collaboration potential.

Exercise offers significant systemic and dermatological benefits, extending beyond cosmetic effects. It has been shown to enhance the expression of genes that play key roles in skin health, such as those involved in collagen synthesis (COL1A2, COL3A1), proteoglycan production (DCN, VCAN), and the biosynthesis of hyaluronic acid (HAS2). These processes are critical for maintaining skin structure and elasticity (16). Additionally, aerobic exercise has been found to stimulate mitochondrial biogenesis in skin fibroblasts, which contributes to skin regeneration by increasing dermal collagen levels. This regenerative process is primarily mediated by interleukin-15 (IL-15), a myokine released during physical activity, which plays a pivotal role in skin tissue repair and remodeling (6,17).

Exercise also promotes the restructuring of the extracellular matrix (ECM), which helps delay the formation of age-related dermal changes, such as the development of "aging bands" in the upper dermis (18). Furthermore, exercise enhances the skin's metabolic response by increasing lower extremity skin temperature and plasma ATP levels, thus supporting thermoregulation and energy distribution (19). The release of cytokines such as IL-5, IL-15, and growth factors like PPAR-γ coactivator-1α and TGF-β1 during physical activity plays a critical role in skin regeneration and protection (6,20). In special populations such as skin cancer survivors, physical activity has even been associated with reduced mortality risk, suggesting a long-term protective effect on skin health (21,22). Additionally, regular physical activity has been shown to enhance mitochondrial function, which aids in maintaining skin moisture and strengthening the skin's barrier function, particularly in the stratum corneum, thereby improving overall skin resilience (23,24).

Integrating research from sports science, dermatology, and aesthetics offers valuable insights into the link between physical activity and skin health, promoting holistic approaches to wellness and preventive care. This interdisciplinary synergy can lead to innovative treatments and personalized health strategies. However, challenges include differences in research methods, terminology, and objectives across fields, which may complicate collaboration. Additionally, research emphasis varies by country developed nations often focus on clinical efficacy and aesthetics, while emerging economies may prioritize accessibility and cultural relevance. Thus, global collaboration requires alignment of goals and sensitivity to diverse health and beauty perspectives

Future research should focus on molecular analyses to directly investigate the mechanisms linking exercise with skin health. By incorporating systematic reviews and meta-analyses, researchers can comprehensively synthesize existing studies and identify key molecular pathways involved in exercise-induced skin regeneration. Collaborative efforts across disciplines, such as dermatology, sports science, and molecular biology, will allow for a deeper understanding of gene expression, cytokine release, and other molecular processes that exercise influences in the skin. Expanding data sources and using diverse analytical methods will enhance the robustness of findings, providing a clearer picture of how physical activity impacts skin health at the molecular level and guiding the development of more targeted, evidence-based interventions.

Despite these promising findings, this study is not without limitations. The data were collected exclusively from a single database Scopus which may have excluded relevant publications indexed in other academic platforms. Furthermore, the restriction to English language articles limits the inclusion of research from non-English speaking regions, potentially overlooking diverse geographical and cultural perspectives. While the bibliometric method provides a valuable quantitative overview of research trends and distribution, it does not delve into the methodological quality or depth of the content of each study.

5. Conclusions

This bibliometric study offers a comprehensive overview of the growing research on the relationship between exercise and skin health, with publications increasing from 2005 to 2025. The results indicate rising scientific interest in the dermatological and aesthetic benefits of physical activity, particularly in recent years, reflecting the global shift toward healthier lifestyles and holistic self-care practices. While the topic has not yet formed a centralized research community, contributions from a wide range of countries, institutions, and disciplines lay a promising foundation for further growth. Keyword analysis highlights the increasing connection between exercise, skin regeneration, and aesthetic improvement. Although emerging evidence supports the physiological mechanisms by which exercise enhances skin elasticity, hydration, and collagen synthesis, there is still a need for more direct clinical trials. This study highlights the emerging link between physical activity and skin health, emphasizing the value of interdisciplinary collaboration. Future research combining clinical trials, meta-analyses, and bibliometric insights can strengthen evidence and inform holistic practices in dermatology and sports medicine. Integrating exercise into skincare strategies may enhance both health outcomes and aesthetic benefits.

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Conflicts of Interest: The authors declare no conflict of interest.

Informed Consent Statement: All data used in this study were obtained from publicly available online databases and did not involve human subjects.

Supplementary Materials: Supplementary data for this study can be obtained by contacting the corresponding author

References

1. Fusco A, Gilic B, Festino E, Papale O. Human Performance and Health in Sport and Exercise. Applied Sciences [Internet]. 2025 Apr 8;15(8):4077. https://doi.org/10.3390/app15084077
2. Ruegsegger GN, Booth FW. Health benefits of exercise. Cold Spring Harb Perspect Med. 2018 Jul 1;8(7). https://doi.org/10.1101/cshperspect.a029694 PMID: 28507196
3. Wang Y, Ashokan K. Physical Exercise: An Overview of Benefits From Psychological Level to Genetics and Beyond. Vol. 12, Frontiers in Physiology. Frontiers Media S.A.; 2021. https://doi.org/10.3389/fphys.2021.731858
4. Vargas NT, Chapman CL, Sackett JR, Johnson BD, Gathercole R, Schlader ZJ. Thermal Behavior Differs between Males and Females during Exercise and Recovery. Med Sci Sports Exerc. 2019 Jan 1;51(1):141–52. https://doi.org/10.1249/MSS.0000000000001756 PMID: 30095750
5. Oizumi R, Sugimoto Y, Aibara H. The Potential of Exercise on Lifestyle and Skin Function: Narrative Review. Vol. 7, JMIR Dermatology. JMIR Publications Inc.; 2024. https://doi.org/10.2196/51962
6. Crane JD, Macneil LG, Lally JS, Ford RJ, Bujak AL, Brar IK, et al. Exercise-stimulated interleukin-15 is controlled by AMPK and regulates skin metabolism and aging. Aging Cell. 2015 Aug 1;14(4):625–34. https://doi.org/10.1111/acel.12341 PMID: 25902870
7. Herbert C. Enhancing Mental Health, Well-Being and Active Lifestyles of University Students by Means of Physical Activity and Exercise Research Programs. Vol. 10, Frontiers in Public Health. Frontiers Media S.A.; 2022. https://doi.org/10.3389/fpubh.2022.849093 PMID: 35548074
8. Passas I. Bibliometric Analysis: The Main Steps. Encyclopedia. 2024 Jun 20;4(2):1014–25. https://doi.org/10.3390/encyclopedia4020065
9. Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM. How to conduct a bibliometric analysis: An overview and guidelines. J Bus Res. 2021 Sep 1;133:285–96. https://doi.org/10.1016/j.jbusres.2021.04.070
10. Ding S. Insights into bibliometric analyses. JBI Evid Synth [Internet]. 2025 Apr;23(4):564–5. https://doi.org/10.11124/JBIES-24-00522
11. Kokol P, Blažun Vošner H, Završnik J. Application of bibliometrics in medicine: a historical bibliometrics analysis. Health Info Libr J. 2021 Jun 1;38(2):125–38. https://doi.org/10.1111/hir.12295 PMID: 31995273
12. Solikhah S, Perwitasari DA, Irham LM, Matahari R. Social Support in Quality of Life among Breast Cancer Patients after Diagnosis: A Bibliometric Analysis. Vol. 75, Siriraj Medical Journal. Faculty of Medicine Siriraj Hospital, Mahidol University; 2023. p. 529–38. https://doi.org/10.33192/smj.v75i7.261979
13. Bakar A, Irham LM, Ningrum V. Publication Trend on Oral Mucositis Induced by Chemotherapy 1978-2023: Bibliometric Analysis. Scripta Medica (Banja Luka). 2024 Sep 1;55(5):631–8. https://doi.org/10.5937/scriptamed55-51528
14. Guerrero-Bote VP, Chinchilla-Rodríguez Z, Mendoza A, de Moya-Anegón F. Comparative Analysis of the Bibliographic Data Sources Dimensions and Scopus: An Approach at the Country and Institutional Levels. Front Res Metr Anal. 2020;5. https://doi.org/10.3389/frma.2020.593494
15. Nuryana Z, Xu W, Lu S. Developing self-esteem-based curriculum as a foundation for sustainable education: A systematic literature review and bibliometric analysis. Vol. 8, Frontiers in Education. Frontiers Media S.A.; 2023. https://doi.org/10.3389/feduc.2023.957801
16. Nishikori S, Yasuda J, Murata K, Takegaki J, Harada Y, Shirai Y, et al. Resistance training rejuvenates aging skin by reducing circulating inflammatory factors and enhancing dermal extracellular matrices. Sci Rep. 2023 Dec 1;13(1). https://doi.org/10.1038/s41598-023-37207-9 PMID: 37353523
17. Hoffmann C, Weigert C. Skeletal muscle as an endocrine organ: The role of myokines in exercise adaptations. Cold Spring Harb Perspect Med. 2017 Nov 1;7(11). https://doi.org/10.1101/cshperspect.a029793 PMID: 28389517
18. Ohshima H, Kinoshita S, Oyobikawa M, Futagawa M, Takiwaki H, Ishiko A, et al. Use of Cutometer area parameters in evaluating age-related changes in the skin elasticity of the cheek. Skin Research and Technology. 2013 Feb;19(1). https://doi.org/10.1111/j.1600-0846.2012.00634.x PMID: 22650601
19. Zarębska EA, Kusy K, Korman P, Słomińska EM, Zieliński J. Exercise-induced changes in lower limbs skin temperature against plasma ATP among individuals with various type and level of physical activity. J Therm Biol. 2024 May 1;122. https://doi.org/10.1016/j.jtherbio.2024.103877 PMID: 38850622
20. Kastella F, Tarawan VM, Setiawan I, Gunawan D, Jasaputra DK, Goenawan H, et al. Potential mechanisms of exercise in maintaining skin homeostasis disrupted by protein deficiency (Review). Vol. 6, World Academy of Sciences Journal. Spandidos Publications; 2024. https://doi.org/10.3892/wasj.2024.235
21. Lavie CJ, Ozemek C, Carbone S, Katzmarzyk PT, Blair SN. Sedentary Behavior, Exercise, and Cardiovascular Health. Vol. 124, Circulation Research. Lippincott Williams and Wilkins; 2019. p. 799–815. https://doi.org/10.1161/CIRCRESAHA.118.312669 PMID: 30817262
22. Cao C, Wang N, Liu R, Patel A V., Friedenreich CM, Yang L. Leisure-time physical activity, daily sitting time, and mortality among US skin cancer survivors. Supportive Care in Cancer. 2023 Dec 1;31(12). https://doi.org/10.1007/s00520-023-08192-6 PMID: 37999788

23. Lu C-Y, Lee H-C, Fahn H-J, Wei Y-H. Oxidative damage elicited by imbalance of free radical scavenging enzymes is associated with large-scale mtDNA deletions in aging human skin. Vol. 423, Mutation Research. 1999.
24. Ryosuke O, Yoshie S. The association between activity levels and skin moisturising function in adults. Dermatol Reports. 2021 Mar 1;13(1). https://doi.org/10.4081/DR.2021.8811