



**GLOBAL TRENDS AND EMERGING RESEARCH THEMES IN EXERCISE
PRESCRIPTION: A BIBLIOMETRIC ANALYSIS**

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ABSTRACT

The scientific literature on exercise prescription has expanded considerably in recent decades; however, no bibliometric analysis has comprehensively mapped its global research trends and thematic evolution. This study aimed to characterize global research trends, collaborative networks, and thematic developments in exercise prescription through a comprehensive bibliometric analysis of Scopus-indexed publications. We analyzed 5,145 publications retrieved from Scopus (1969-June 2026), authored by 20,099 individuals across 1,609 journals, using Bibliometrix/Biblioshiny and VOSviewer to examine publication trends, citation performance, author and country productivity, journal influence, and keyword co-occurrence patterns. The dataset showed a robust annual growth rate of 11.26%, an international co-authorship rate of 22.13%, and an average of 29.62 citations per document. Output expanded markedly after 2010, peaking at 553 publications in 2025, coinciding with heightened global attention to exercise as a therapeutic strategy during the COVID-19 pandemic. The United States, Australia, Canada, and the United Kingdom were the most productive and influential contributors, with Medicine and Science in Sports and Exercise as the leading journal. Keyword co-occurrence analysis identified 605 keywords across 16 thematic clusters, with established themes centered on aerobic exercise, cardiac rehabilitation, and chronic disease management, alongside emerging themes in precision medicine, telehealth, myokines, and velocity-based training. Despite growing collaboration, research partnerships remain unevenly distributed globally, underscoring the need for greater international cooperation and integration of emerging technologies into future exercise prescription frameworks.

Keywords: bibliometric analysis; exercise prescription; international collaboration; precision medicine; scientific mapping

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INTRODUCTION

Physical inactivity remains one of the most pressing modifiable risk factors contributing to global morbidity and mortality, with insufficient physical activity documented across all income groups and geographic regions worldwide (Bull et al., 2020; Ekelund et al., 2020). Its consequences extend across a wide spectrum of non-communicable diseases, including cardiovascular disease, type 2 diabetes, obesity, certain cancers, and mental health disorders (Bull et al., 2020). The COVID-19 pandemic further amplified these concerns, as enforced sedentariness and disruption to routine physical activity patterns exposed and deepened existing health vulnerabilities at a global scale (Chen et al., 2020). In this context, exercise prescription, the systematic and individualized recommendation of physical activity based on frequency, intensity, time, and type, has assumed increasing prominence as a clinical and public health strategy (Ross et al., 2019).

The scientific foundation of exercise prescription has evolved considerably in recent years, driven by major guidelines and consensus documents from leading international bodies. The World Health Organization's 2020 guidelines on physical activity and sedentary behavior represented a landmark expansion of evidence-based recommendations to encompass populations across all age groups and health conditions (Bull et al., 2020). Similarly, the 2020 European Society of Cardiology guidelines on sports cardiology underscored the growing clinical relevance of structured exercise for patients

with established cardiovascular disease (Pelliccia et al., 2021). Beyond cardiovascular health, recent expert consensus documents have addressed exercise recommendations for older adults (Izquierdo et al., 2021), cancer survivors, and individuals with metabolic disorders, reflecting the broadening clinical applicability of exercise prescription across diverse patient populations. Despite this progress, significant challenges persist in translating evidence-based guidelines into practice, particularly regarding optimal prescription parameters for specific clinical contexts and the integration of emerging precision health technologies into exercise delivery (Ramírez-Vélez & Izquierdo, 2022).

Bibliometric analysis has been established as a rigorous and increasingly adopted methodology for quantitatively evaluating the structure, evolution, and thematic priorities of scientific knowledge within a given research domain (Donthu et al., 2021). By systematically mapping publication trends, citation networks, author collaborations, and keyword co-occurrence patterns, bibliometric approaches provide a comprehensive and data-driven perspective on the intellectual landscape of a field that traditional narrative reviews are unable to offer at scale (Aria & Cuccurullo, 2017). Advances in bibliometric software tools have further expanded the accessibility and analytical depth of such analyses, enabling researchers to generate network visualizations and thematic maps that reveal both established research structures and emergent frontiers (Aria & Cuccurullo, 2017; Moral-Muñoz et al., 2020).

Despite the substantial and rapidly expanding body of literature on exercise prescription, no comprehensive bibliometric analysis has been conducted to systematically characterize its global research trends, collaborative networks, and thematic developments as a whole. Previous reviews have addressed specific subdomains, including exercise oncology, cardiac rehabilitation, and digital exercise delivery, but a field-wide bibliometric perspective that integrates the full scope of exercise prescription research remains absent. Such an analysis is essential to provide clinicians, researchers, and policymakers with a data-driven understanding of the field's current state and emerging priorities. Therefore, this study aimed to conduct a comprehensive bibliometric analysis of global exercise prescription research indexed in the Scopus database, with the objectives of characterizing annual scientific production trends, identifying the most influential publications, authors, institutions, and countries, mapping international collaboration networks, and delineating the major and emerging thematic clusters that define the evolving landscape of this field.

METHOD

Data Source and Search Strategy

Bibliographic data were retrieved exclusively from the Scopus database, selected for its broad multidisciplinary coverage, standardized bibliographic information, and compatibility with bibliometric analysis software. A systematic literature search was performed on June 30, 2026, using the search term “exercise prescription” applied to the Title, Abstract, and Keywords fields. The search strategy was intentionally kept simple to maximize reproducibility while ensuring comprehensive retrieval of publications directly related to exercise prescription. The initial search identified 6,097 records.

Eligibility Criteria

Retrieved publications were screened according to predefined eligibility criteria. Publications categorized as book chapters ($n = 237$), notes ($n = 60$), editorials ($n = 52$), and books ($n = 32$) were excluded, resulting in 5,602 eligible records. A language restriction was then applied to include only publications written in English, excluding 544 non-English publications across 18 languages. Following the screening process, the final dataset comprised 5,145 publications eligible for bibliometric analysis. The complete study selection process is illustrated in Figure 1.

Data Extraction

Eligible publications were exported from Scopus in CSV format, including complete bibliographic metadata comprising publication year, document type, authors, institutional affiliations, countries, source journals, citation counts, references, abstracts, and author keywords.

Bibliometric Analysis

Bibliometric analyses were conducted using the Bibliometrix package through the Biblioshiny interface in the R environment. Descriptive analyses included annual scientific production, annual growth rate, citation performance, most productive authors, influential journals, productive institutions, and leading countries.

Network Visualization

Network visualization was performed using VOSviewer version 1.6.21 to examine relationships among authors, institutions, countries, cited references, and keywords. Co-authorship, co-citation, bibliographic coupling, and keyword co-occurrence analyses were conducted to identify collaboration patterns, intellectual structures, and emerging research themes. Overlay and density visualization maps were generated to illustrate the temporal evolution and research hotspots within the field of exercise prescription.

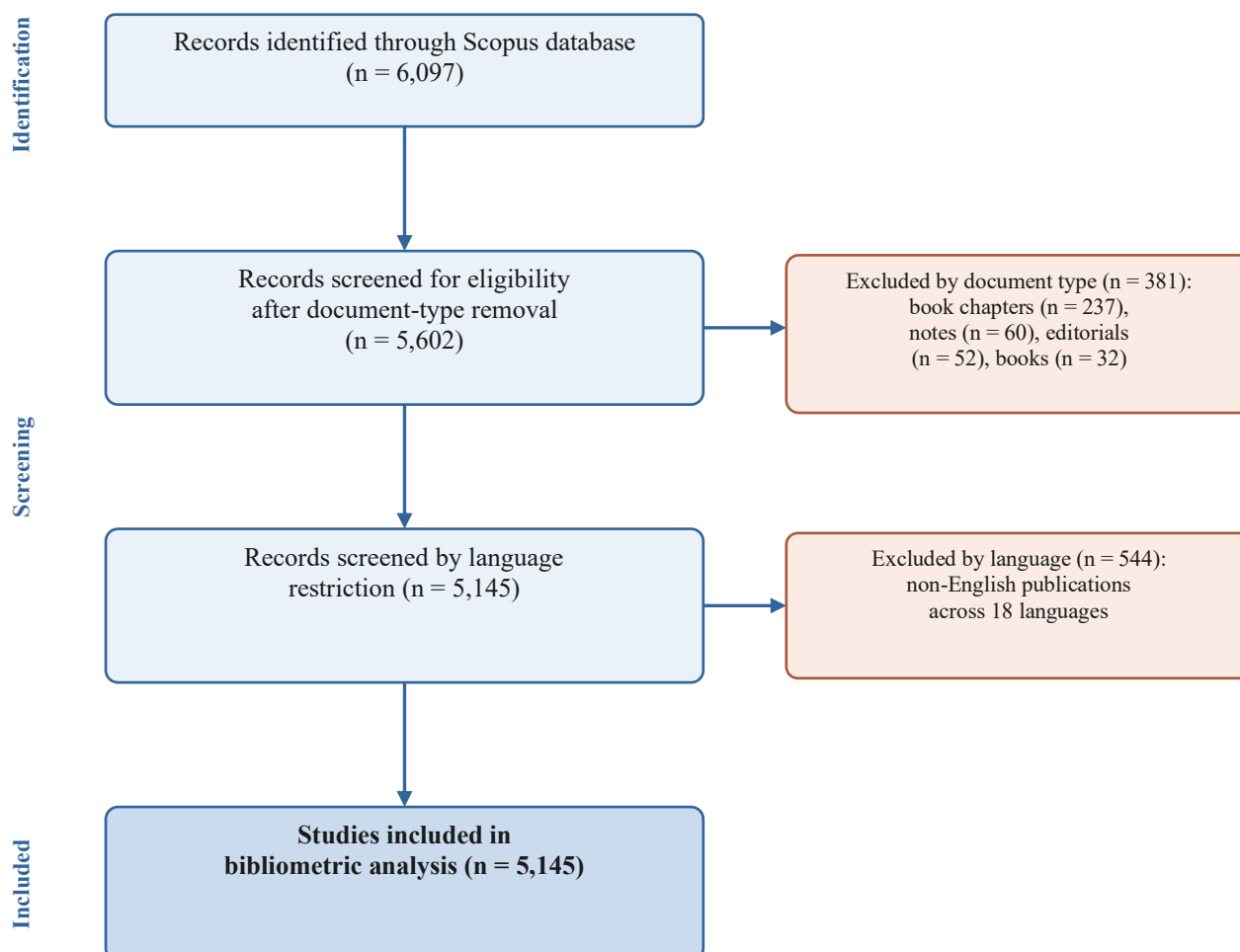


Figure 1. PRISMA flow diagram of the study selection process.

RESULT

Study Selection and Dataset Overview

A systematic search of the Scopus database on June 30, 2026, using the term “exercise prescription” in the Title, Abstract, and Keywords fields retrieved 6,097 documents. After applying predefined eligibility criteria excluding non-original document types and non-English publications, a final dataset of 5,145 publications was retained for bibliometric analysis. The complete study selection process is presented in Figure 1.

The dataset spanned a publication period from 1969 to June 2026, with contributions from 20,099 authors publishing across 1,609 distinct journals. Each document received an average of 29.62 citations, with an average co-authorship rate of 5.29 authors per document. The rate of international co-authorship reached 22.13%, highlighting the global and collaborative nature of exercise prescription research.

Annual Scientific Production and Growth Rate

Research on exercise prescription showed minimal scientific activity from 1969 through the early 1980s, with fewer than 10 articles published annually. A gradual but consistent rise followed through the 1990s and early 2000s, reflecting the progressive consolidation of exercise prescription as a recognized scientific discipline. A more pronounced acceleration emerged from 2010 onward, with annual output exceeding 100 documents for the first time and continuing to rise substantially through the following decade.

The most notable surge occurred between 2020 and 2025, coinciding with heightened global attention to exercise as a therapeutic and preventive intervention, particularly in the context of chronic disease management and the health consequences of the COVID-19 pandemic, and culminating in a peak of 553 publications in 2025, the highest annual output across the entire study period. A modest decline was observed in 2026, most likely attributable to incomplete database indexing rather than an actual reduction in research activity (Figure 2). Overall, an annual growth rate of 11.26% confirms a robust and sustained expansion of scientific interest in this field.

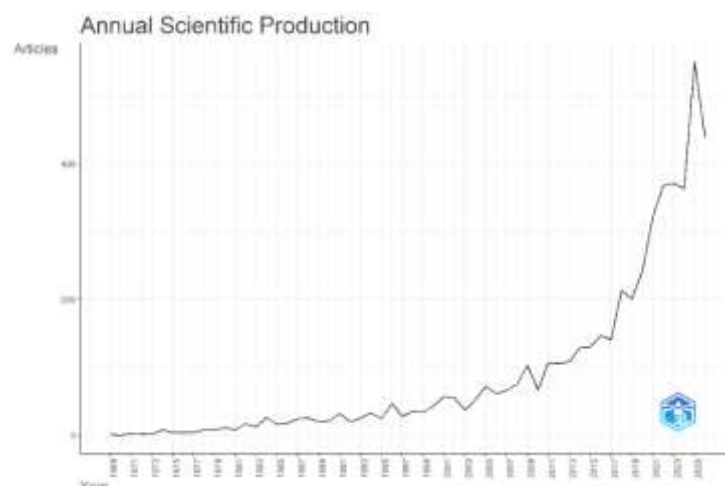


Figure 2. Annual scientific production on exercise prescription from 1969 to June 2026 (n = 5,145 documents). Note: The decline observed in 2026 reflects incomplete indexing at the time of data extraction (June 30, 2026).

Citation Performance and Most Cited Documents

The dataset demonstrated strong citation impact, with an average of 29.62 citations per document. As illustrated in Figure 3, average citations per year showed a generally increasing trend, reaching its highest point in the early 2000s, a period marked by the publication of several landmark clinical

guidelines, before declining in recent years, consistent with the recency effect commonly observed in bibliometric analyses.

The ten most globally cited documents are presented in Table 1. The most influential publication was the ACSM position stand on exercise and physical activity for older adults by Chodzko-Zajko et al. (2009), which has accumulated citations substantially exceeding all other documents in the dataset, underscoring its foundational role in shaping subsequent research. Other highly cited works addressed resistance training, cardiovascular rehabilitation, stroke recovery, and exercise for cognitive function and cancer survivors, collectively reflecting the broad clinical scope and multi-domain influence of exercise prescription science.

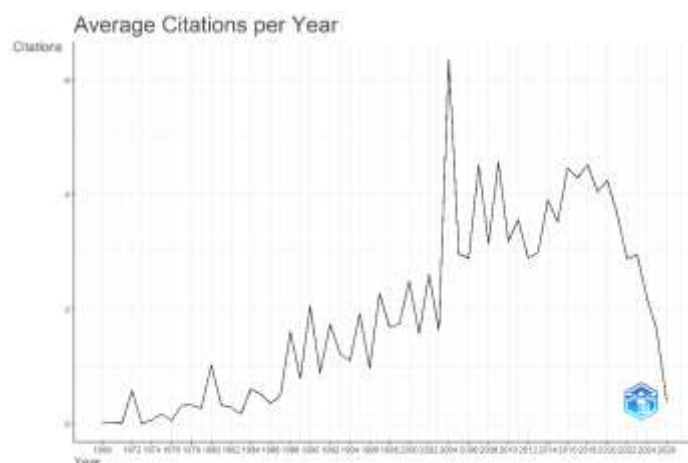


Figure 3. Average citation per year on exercise prescription publications (1969–June 2026). Source: Biblioshiny/Bibliometrix analysis.

Table 1.

Top 10 most globally cited documents in exercise prescription research.

Rank	Author(s)	Year	Journal	Global Citation
1	Chodzko-Zajko WJ et al.	2009	Medicine and Science in Sports and Exercise	3,352
2	NA	2004	Medicine and Science in Sports and Exercise	1,502
3	Kraemer WJ et al.	2004	Medicine and Science in Sports and Exercise	1,487
4	Jetté M et al.	1990	Clinical Cardiology	1,226
5	Billinger SA et al.	2014	Stroke	1,217
6	Ettinger WH Jr et al.	1997	JAMA	1,213
7	Northey JM et al.	2018	British Journal of Sports Medicine	1,122
8	Ekkekakis P et al.	2011	Sports Medicine	1,065
9	Izquierdo M et al.	2021	Journal of Nutrition Health and Aging	1,007
10	Severinsen MCK et al.	2020	Endocrine Reviews	985

Note. Citation counts are as recorded in Scopus at the time of data extraction (June 30, 2026). NA = author information not available in the source record.

Most Productive Authors, Institutions, and Countries

The analysis of author productivity revealed Newton, Robert U. as the most prolific contributor in the field, followed by Pescatello, Linda S., Foster, Carl, and Myers, Jonathan, as illustrated in Figure 4. The research domains represented by these leading authors collectively span resistance training, hypertension management, cardiopulmonary rehabilitation, and exercise oncology. Authors with the longest scientific trajectories, including Franklin, Barry A. and Foster, Carl, have maintained continuous contributions since the mid-1980s, while researchers such as Galvão, Daniel A. and Campbell, Kristin L. have emerged more recently with sustained high-volume output, particularly in cancer exercise research.

At the institutional level, the University of British Columbia led global production, followed by Beijing Sport University and the University of Toronto. Australian institutions, including Edith Cowan University, Monash University, The University of Queensland, and the University of

Sydney, were strongly represented among the top affiliations, highlighting Australia's substantial contribution to exercise prescription research. In terms of country-level citation impact, the United States demonstrated the most dominant contribution, followed by Australia, Canada, and the United Kingdom. The rapidly growing presence of Chinese institutions signals an expanding contribution from East Asian research communities. The geographic distribution of scientific production is illustrated in Figure 5.



Figure 4. The ten most productive authors in exercise prescription research ranked by number of publications (1969–June 2026).



Figure 5. Geographic distribution of scientific production on exercise prescription research (1969–June 2026).

Most Influential Journals

The 5,145 publications were distributed across 1,609 distinct sources. Medicine and Science in Sports and Exercise emerged as the most productive journal, followed by the Journal of Strength and Conditioning Research and Sports Medicine (Figure 6). The concentration of leading journals in sports medicine, exercise physiology, and clinical rehabilitation reflects the inherently multidisciplinary nature of exercise prescription research. Notably, the International Journal of Environmental Research and Public Health and the Journal of Clinical Medicine also featured among the top sources, underscoring the growing intersection of exercise prescription with public health and preventive medicine.

Bradford's Law analysis (Figure 7) identified a core group of journals responsible for approximately one-third of all publications, with a Bradford multiplier of $k = 4.93$ and a high goodness-of-fit value ($R^2 = 0.9873$), confirming that the distribution closely follows Bradford's Law, a pattern characteristic of well-established scientific fields in which a small nucleus of specialized journals exerts disproportionate influence over the broader literature.

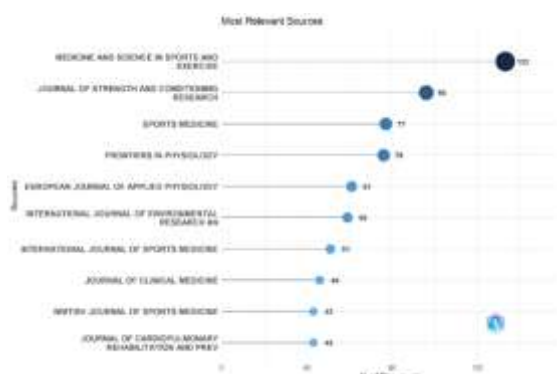


Figure 6. The ten most productive journals in exercise prescription research ranked by number of publications (1969–June 2026).

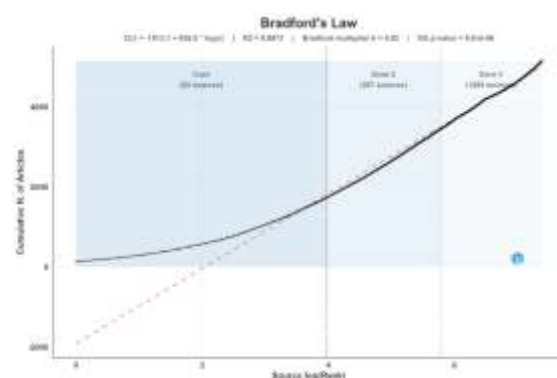


Figure 7. Bradford's Law distribution of journals publishing exercise prescription research (core zone: 53 journals; zone 2: 267 journals; zone 3: 1,289 journals; Bradford multiplier $k = 4.93$, $R^2 = 0.9873$).

Co-Authorship and Country Collaboration Network

The country co-authorship network analysis identified 58 countries meeting the minimum threshold, forming an interconnected network comprising six distinct collaborative clusters (Figure 8). The United States occupied the most central position as the primary hub of international research collaboration, with Australia, the United Kingdom, Canada, and China serving as the most prominent partner nations. European countries, particularly those in Western and Northern Europe, formed a cohesive collaborative cluster, while a well-established East Asian network centered on China, South Korea, Japan, and several Southeast Asian nations was also evident.

The overlay visualization revealed that East Asian nations displayed the most recent collaborative activity, confirming a growing geographic diversification of exercise prescription research. Despite this expanding international engagement, the majority of publications arose from nationally concentrated collaborations, suggesting that global research partnerships in this field, while increasing, remain unequally distributed across regions.

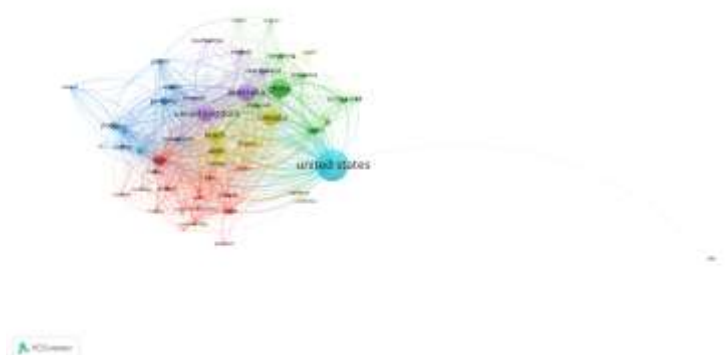


Figure 8. Country co-authorship network visualization in exercise prescription research. Node size represents number of publications; line thickness represents collaboration strength.

Keyword Co-Occurrence and Emerging Research Themes

Keyword co-occurrence analysis identified 605 keywords forming 16 thematic clusters (Figure 9). The most frequently occurring and centrally positioned keywords included “exercise,” “aerobic exercise,” “rehabilitation,” “cardiac rehabilitation,” and “quality of life,” reflecting the field’s established orientation toward cardiovascular and clinical rehabilitation outcomes. Additional major clusters encompassed chronic disease and metabolic health, including obesity, diabetes, and blood pressure management, as well as a distinct cluster representing exercise oncology and aging, featuring keywords related to cancer survivors, geriatric populations, and age-related physical decline.

The overlay visualization (Figure 10) provided critical insight into the temporal evolution of research themes across the study period. Keywords reflecting foundational research domains displayed earlier temporal coloration, confirming their status as well-established themes. In contrast, a distinct set of more recent keywords, including “precision medicine,” “telehealth,” “digital health,” “myokines,” “mitochondria,” “velocity-based training,” and “lifestyle medicine,” displayed the most recent coloration, signaling an ongoing transition in the field toward individualized, technology-assisted, and molecularly informed approaches to exercise prescription. This thematic evolution indicates that exercise prescription research is progressively moving beyond population-level recommendations to embrace precision health frameworks and digital delivery platforms as central research priorities.

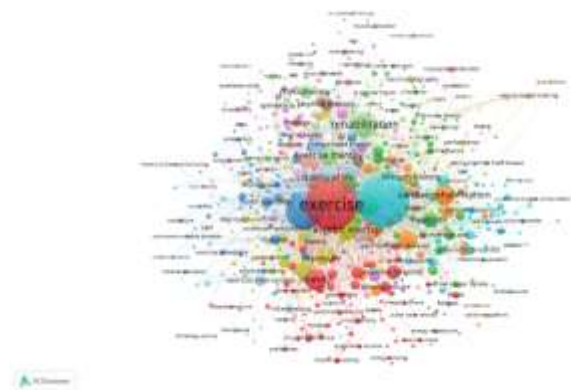


Figure 9. Author keyword co-occurrence network visualization in exercise prescription research (n = 605 keywords). Node size represents keyword frequency; line thickness represents co-occurrence strength.

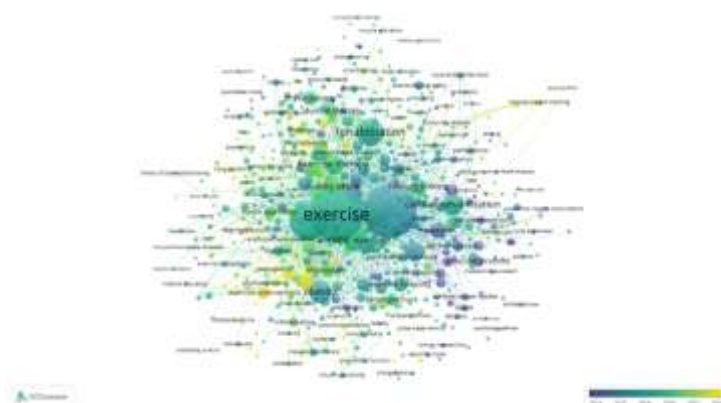


Figure 10. Overlay visualization of author keyword co-occurrence network, illustrating the temporal evolution of research themes (color scale: dark blue = earlier; yellow-green = more recent).

DISCUSSION

This bibliometric analysis of exercise prescription research spanning 1969 through June 2026 illustrates a field that has expanded substantially in both volume and thematic diversity, propelled by the convergence of clinical demand, public health priorities, and technological innovation. Annual scientific production rose steadily throughout the study period, with the sharpest acceleration occurring from 2020 onward and peaking in 2025. This surge coincides with the COVID-19 pandemic, which redirected global scientific attention toward exercise-based strategies for countering the health consequences of pandemic-induced inactivity and post-acute infection sequelae (Halle et al., 2021; Jiménez-Pavón et al., 2020). The disproportionate vulnerability of physically inactive populations to severe disease outcomes generated urgent scientific and policy interest in exercise promotion (Lippi et al., 2020; Sallis et al., 2021), a pattern of crisis-driven publication growth also documented across other biomedical fields (Chen et al., 2020). The pandemic additionally accelerated research at the intersection of exercise prescription and remote care, reflected in expanding evidence for home-based and telehealth-delivered rehabilitation models that achieve outcomes comparable to center-based programs (Batalik et al., 2020; Ramachandran et al., 2022; Scherrenberg et al., 2021).

Citation and source analyses converged on a similar conclusion: authoritative clinical frameworks anchor the field. ACSM position statements and major international guidelines emerged as the most influential documents, with a citation peak in the early 2000s corresponding to landmark guidance that redefined the evidence base of exercise prescription (Bull et al., 2020; Pelliccia et al., 2021), a pattern consistent with other mature clinical domains in which consensus documents sustain long-term citation impact beyond individual studies (Donthu et al., 2021). Bradford's Law confirmed that

a small nucleus of specialized journals, led by Medicine and Science in Sports and Exercise, accounts for a disproportionate share of output, typical of an established biomedical field with a limited number of high-impact outlets (Aria & Cuccurullo, 2017). The growing presence of multidisciplinary public health journals among the top sources further reflects the convergence of exercise prescription with preventive medicine and population-level physical activity policy (Bull et al., 2020).

Geographically, the United States led in both publication volume and citation impact, reflecting its research infrastructure and leadership in international exercise guidelines (Bull et al., 2020; Pelliccia et al., 2021), followed by Australia, Canada, and the United Kingdom. China's rising institutional presence mirrors broader East Asian investment in sports medicine amid an expanding chronic disease burden (Bull et al., 2020), although global collaboration networks, while growing, remain unevenly distributed and nationally concentrated (Donthu et al., 2021). Author productivity analysis likewise revealed a small group of prolific researchers spanning resistance training, hypertension management, cardiopulmonary rehabilitation, and exercise oncology, a domain whose translation into routine clinical coverage continues to face policy and reimbursement barriers (Kennedy et al., 2023; Maestroni et al., 2020), with output concentrated among established researchers in a manner characteristic of cumulative advantage in mature scientific fields (Donthu et al., 2021).

Keyword co-occurrence analysis identified cardiac rehabilitation, aerobic exercise, obesity, and blood pressure management as enduring thematic pillars, reflecting decades of evidence supporting physical activity as a cornerstone cardiometabolic intervention, alongside a prominent rehabilitation and aging-related cluster relevant to older adults and chronic disease populations. More critically, the overlay visualization revealed a pronounced shift toward recently active keywords, including precision medicine, telehealth, digital health, myokines, and velocity-based training, signaling a transition toward individualized and technology-assisted prescription. This trajectory aligns with an emerging body of work on exercise response variability, underscoring that a single prescription rarely fits all individuals and calling for phenotype- and genotype-informed programming (Noone et al., 2024; Ross et al., 2019). Artificial intelligence tools are beginning to enter this space as adjuncts for individualizing prescriptions, although current evidence suggests they remain limited in clinical precision and cannot yet substitute for professional judgment (Dergaa et al., 2024). In parallel, the emergence of myokines as a focal research theme reflects deepening interest in the molecular basis of exercise-induced health benefits, building on the recognition of skeletal muscle as a secretory endocrine organ capable of mediating systemic metabolic and anti-inflammatory effects (Chow et al., 2022; Febbraio & Pedersen, 2020; Nishii et al., 2023; Severinsen & Pedersen, 2020).

This study has limitations inherent to bibliometric methodology. The dataset was restricted to English-language publications indexed in Scopus, which may not fully capture research published in other languages or indexed in Web of Science or PubMed (Martín-Martín et al., 2021; Singh et al., 2021), and citation-based indicators may favor older, high-impact-journal publications over more recent open-access scholarship. Keyword co-occurrence analysis also captures only the thematic dimensions explicitly expressed through standardized author keywords and may underrepresent emerging interdisciplinary connections not yet reflected in established conventions. Future bibliometric studies would benefit from multi-database approaches and semantic analysis methods to more comprehensively map the evolving research landscape of exercise prescription.

CONCLUSION

The research landscape of exercise prescription has expanded substantially over the past five decades, with an annual growth rate of 11.26% and a marked surge in publications following the COVID-19 pandemic. The United States, Australia, and Canada emerged as the leading contributors in terms of both publication volume and citation impact, while the growing presence of Chinese

institutions signals a broadening geographic diversity in global exercise prescription research. *Medicine and Science in Sports and Exercise* was identified as the most influential journal, with major international guidelines, including ACSM position statements and WHO physical activity recommendations, consistently constituting the most influential documents in the field, reflecting the scientific community's reliance on authoritative frameworks to anchor research and clinical practice.

Keyword analysis revealed that foundational themes, including cardiac rehabilitation, aerobic exercise, and chronic disease management, continue to anchor the field. Critically, the overlay visualization identified a clear shift toward emerging research priorities, including precision medicine, telehealth, digital health, myokines, and velocity-based training, indicating a transition toward individualized and technology-assisted approaches to exercise prescription. This thematic evolution reflects the field's growing aspiration to move beyond population-level recommendations toward precision health frameworks tailored to individual patient characteristics.

This study has several limitations. Data were restricted to English-language publications indexed in the Scopus database, which may not fully capture research from other databases or non-English sources. Future studies should consider multi-database approaches to enhance the comprehensiveness of bibliometric analyses in this domain. This bibliometric analysis provides a valuable reference framework for clinicians and researchers to navigate the evolving landscape of exercise prescription science and to identify priority areas for future investigation.

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