Clinical and Pharmaceutical Sciences Journal

Review article

Global Research Trends in Sarcopenia (1994–2024): A Bibliometric and Thematic Evolution Analysis with Implications for Future Research

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Received: 27 August 2026 | Revision: 29 October 2026 | Accepted: 30 October 2026

Abstract

Sarcopenia has attracted increasing scientific attention because of its implications for ageing, physical function, and health outcomes. This study aimed to map the global research landscape of sarcopenia by examining publication trends, leading contributors, influential research sources, thematic evolution, and emerging research directions using bibliometric and thematic network analyses. A bibliometric analysis was conducted using publications indexed in the Scopus database between 1994 and 2024. Documents containing the term "sarcopenia" in their titles were retrieved and analysed using Bibliometrix in R. The analysis examined scientific productivity, author and journal contributions, geographical distribution, keyword patterns, thematic evolution, and emerging research themes. A total of 7,837 sarcopenia-related publications were identified. Annual scientific output increased markedly after 2010, reaching its highest level in 2024. Landi F was the most productive author, while the Journal of Cachexia, Sarcopenia and Muscle published the largest number of documents. China was the leading contributing country in terms of publication output. Frequently occurring author keywords included "sarcopenia," "fatality," and "muscle mass." Thematic evolution across four time intervals identified research topics related to cystatin C, creatinine, older adults, diabetes mellitus, and stroke. Additional thematic analyses highlighted Mendelian randomisation, ageing, prognosis, machine learning, myostatin, SARC-F, and biomarkers, particularly cystatin C, as prominent areas of investigation. Global sarcopenia research has expanded substantially, accompanied by increasing thematic diversity and growing attention to molecular mechanisms, biomarkers, and predictive approaches. The prominence of cystatin C, myostatin, Mendelian randomisation, machine learning, and SARC-F suggests an expanding research focus beyond disease definition and diagnosis toward risk assessment and mechanistic investigation. These findings identify potential priorities for future research, including biomarker validation, external validation of prediction models, and clinical evaluation of mechanism-based therapeutic strategies. Greater international collaboration and integration of bibliometric findings with clinical evidence may further support the translation of emerging research directions into sarcopenia management.

Keywords: Bibliometrix, sarcopenia, scopus database, thematic evaluation

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Introduction

Sarcopenia has emerged as a major global public health concern, particularly in the context of population ageing, with its prevalence expected to increase substantially in the coming decades [1]. Sarcopenia is a skeletal muscle disorder characterised by progressive declines in muscle mass and function, commonly associated with ageing [2]. The term sarcopenia was originally introduced by Rosenberg to describe the age-related loss of skeletal muscle mass, and its conceptual definition has subsequently evolved to incorporate muscle strength and physical performance as important clinical dimensions [3]. Growing recognition of sarcopenia reflects its substantial implications for physical independence, functional capacity, and overall health among older adults.

The development and progression of sarcopenia are influenced by multiple factors, including physical inactivity, nutritional status, age-related physiological changes, and underlying health conditions [4,5]. Although sarcopenia is predominantly associated with older populations, evidence suggests that changes in skeletal muscle health may begin

earlier in adulthood and accumulate throughout the life course [6]. Ageing itself is a complex, multifactorial process involving alterations in body composition, including reductions in skeletal muscle and bone mass and changes in adipose tissue distribution. These physiological changes may contribute to functional impairment, metabolic disturbances, disability, reduced quality of life, and increased morbidity and mortality [6]. Furthermore, sarcopenia has been associated with an increased risk of falls and hospitalisation among older adults [7].

The clinical understanding of sarcopenia has evolved considerably over time. In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) proposed a consensus definition incorporating low muscle mass, reduced muscle strength, and impaired physical performance [7,8]. Sarcopenia may also be classified as primary, when predominantly associated with ageing, or secondary, when related to factors such as physical inactivity, disease, or inadequate nutrition [9]. This distinction highlights the heterogeneous and multifactorial nature of sarcopenia and its relevance beyond physiological ageing alone. Consequently, effective prevention and management require multidimensional approaches that address both skeletal muscle health and modifiable risk factors.

Nutritional interventions and structured physical exercise are widely recognised as important components of sarcopenia management. Nutritional strategies emphasising adequate protein intake, dietary quality, and appropriate fatty acid composition have been investigated for their potential to support muscle health and physical function [10]. Previous studies have also reported associations between smoking cessation, adequate nutritional status, early rehabilitation, and a reduced risk of sarcopenia [11]. In addition, regular physical activity has demonstrated beneficial effects on metabolic and cardiovascular health [12], while exercise-based interventions have been recognised as important strategies for preserving muscle strength and function in individuals with sarcopenia [13]. Nevertheless, the complexity of sarcopenia pathophysiology and its diverse clinical manifestations have encouraged research extending beyond conventional diagnostic and lifestyle-related approaches toward molecular mechanisms, biomarkers, and emerging therapeutic strategies.

Alongside these clinical developments, the volume and diversity of sarcopenia-related scientific literature have increased substantially, creating a need for systematic approaches to evaluating the structure and evolution of the research field. Bibliometric analysis provides a quantitative framework for examining scientific publications through mathematical and statistical techniques, enabling the identification of publication trends, influential contributors, citation patterns, collaborative networks, and emerging research topics [14–19]. By integrating publication metadata with network-based visualisation techniques, bibliometric methods can reveal relationships among authors, institutions, countries, and research themes that may be difficult to identify through conventional narrative reviews [17–19]. Recent applications of bibliometric and thematic analyses in oncology, including research involving artificial intelligence and machine learning, have demonstrated their utility in mapping scientific development and identifying emerging research directions [16,20].

Previous bibliometric studies have contributed valuable insights into the global development of sarcopenia research. Yuan et al. [2] examined publication trends, influential authors, and geographical contributions in sarcopenia-related literature up to 2021, providing an overview of the field's scientific productivity. Other investigations, including the study by Mohammed and Li [21], have focused on specific research intersections, such as the relationship between sarcopenia and cancer. Although these studies have improved understanding of publication patterns and research contributions, they provide a more limited perspective on the longitudinal development of thematic priorities across the broader sarcopenia literature. In particular, the evolution of research themes associated with biomarkers, machine learning, Mendelian randomisation, and molecular mechanisms warrants further examination within a comprehensive historical framework.

To address this gap, the present study conducts a bibliometric analysis of Scopus-indexed publications on sarcopenia from 1994 to 2024, integrating scientific productivity indicators with thematic evolution and strategic diagram analyses. Specifically, this study aims to (i) characterise global publication trends and identify leading authors, journals, and contributing countries; (ii) examine the longitudinal evolution of research themes across distinct time intervals; and (iii) identify prominent and emerging research directions, particularly those related to biomarkers, molecular mechanisms, predictive modelling, and therapeutic development. By combining quantitative bibliometric indicators with thematic mapping, this study seeks to provide a comprehensive perspective on the intellectual development of sarcopenia research and identify priorities for future investigation and international scientific collaboration.

Given the increasing global public health burden of sarcopenia and the rapid expansion of related scientific literature, a comprehensive evaluation of the field's research development is warranted. This study aims to provide an overview of global sarcopenia research from 1994 to 2024 by analysing Scopus-indexed publications using bibliometric methods and conceptual and intellectual network visualisation. Specifically, the study examines the evolution of scientific productivity, identifies influential publications, authors, institutions, countries, and journals, and evaluates their contributions through publication and citation-based indicators. Furthermore, keyword co-occurrence analysis, thematic mapping, and thematic evolution analysis are employed to identify dominant research themes,

explore relationships among major research topics, and trace changes in scientific priorities over time. Particular attention is given to the development of research interests related to disease definition, diagnostic approaches, underlying mechanisms, biomarkers, prevention, and therapeutic management. By integrating bibliometric performance indicators with longitudinal thematic analysis, this study seeks to provide a deeper understanding of the intellectual development of sarcopenia research, identify emerging areas of investigation, and highlight potential priorities for future research and international scientific collaboration.

Materials and Methods

Materials

The primary data source for this study was the Scopus database (https://www.scopus.com/), a multidisciplinary bibliographic and citation database widely used for scientific performance evaluation and bibliometric research [17,23–25]. Scopus provides structured metadata on scholarly publications, including titles, abstracts, authors, institutional affiliations, journal information, publication years, author keywords, citation counts, and cited references. These bibliographic records enable the quantitative assessment of scientific productivity, citation performance, research collaboration, and the conceptual and intellectual structures of a research field [25,26].

The study focused on English-language research articles and reviews related to sarcopenia published between 1994 and 2024. Bibliographic records were retrieved from Scopus on February 25, 2025, through the electronic library portal of The Chinese University of Hong Kong. Following the reported identification and screening procedures, 7,837 publications were included in the final dataset. The retrieved metadata were exported in comma-separated values (CSV), Research Information Systems (RIS), and BibTeX formats for subsequent bibliometric processing.

Additional journal-level information, including Journal Impact Factors and CiteScore indicators, was obtained from Clarivate's Journal Citation Reports and Scopus Journal Metrics, respectively. These indicators were considered supplementary measures for characterising the publication sources represented in the dataset.

Methods

Study design

This study employed a descriptive and analytical bibliometric design to examine global scientific productivity and research developments in sarcopenia from 1994 to 2024. The methodological approach was informed by previous bibliometric investigations in medical and health sciences [20,22]. Bibliometric performance analysis and science mapping were used to characterise publication trends, identify influential contributors, examine citation relationships, and explore the conceptual development of sarcopenia research. The study incorporated quantitative bibliometric indicators and thematic network analyses to investigate scientific contributions and changes in research priorities over time. The identification and selection of publications were documented using a PRISMA-based flow diagram (Figure 1).

Search strategy and eligibility criteria

The literature search was conducted in Scopus on February 25, 2025. Two researchers (THM and HHM) reviewed terminology associated with sarcopenia to inform the search strategy. The search was restricted to publications containing the term “sarcopenia” in the title, with the intention of identifying literature in which sarcopenia constituted an explicit research focus. The eligibility criteria were defined as follows: publications were required to (i) address sarcopenia as indicated by the title search; (ii) fall within the study period of 1994–2024; (iii) be classified as original research articles or review articles; and (iv) be published in English. Documents classified as conference papers, book chapters, editorials, letters, notes, errata, short surveys, books, and retracted publications were excluded.

The search strategy was based on the following Scopus query, presented here in a corrected form consistent with the stated eligibility criteria: TITLE(sarcopenia*) AND PUBYEAR > 1993 AND PUBYEAR < 2025 AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "re")) AND LIMIT-TO(LANGUAGE, "English")

Restricting the search to publication titles was intended to increase the specificity of the retrieved records. However, this approach may have excluded relevant studies addressing related concepts, including frailty, dynapenia, muscle quality, and age-related functional decline, without explicitly mentioning sarcopenia in their titles. Accordingly, the dataset primarily represents publications explicitly identified as sarcopenia research rather than the entire literature concerning skeletal muscle ageing and functional impairment.

Data collection and preparation

Bibliometric analysis was conducted using Bibliometrix in the R statistical computing environment. The analysis examined annual scientific production, author productivity, institutional and country contributions, journal

performance, and citation-based indicators. These measures were used to characterise the distribution and development of sarcopenia-related scientific publications over the study period.

Conceptual structure analysis was undertaken using keyword-based bibliometric techniques to identify prominent research topics and relationships among thematic areas. Thematic mapping and thematic evolution analyses were employed to examine the development of research themes across different periods, with particular attention to topics related to sarcopenia diagnosis, ageing, disease mechanisms, biomarkers, predictive approaches, prevention, and therapeutic management.

The resulting bibliometric indicators and thematic visualisations were interpreted descriptively to identify established research areas, developing topics, and potential future research directions. Because bibliometric indicators primarily reflect publication and citation patterns, they were not considered direct measures of methodological quality or clinical effectiveness.

Bibliometric indicators and citation analysis

Descriptive bibliometric analysis was performed using Bibliometrix to characterize research productivity and scientific impact. The indicators examined included annual publication output, publication growth rates, average citations per document, authorship characteristics, and the productivity of authors, journals, institutions, and countries. Citation analysis was conducted to assess the scholarly influence of publications and research contributors based on citation-related indicators. The analysis also examined the distribution of research output across countries and institutions to identify major contributors to pediatric cardiac intervention and surgery research.

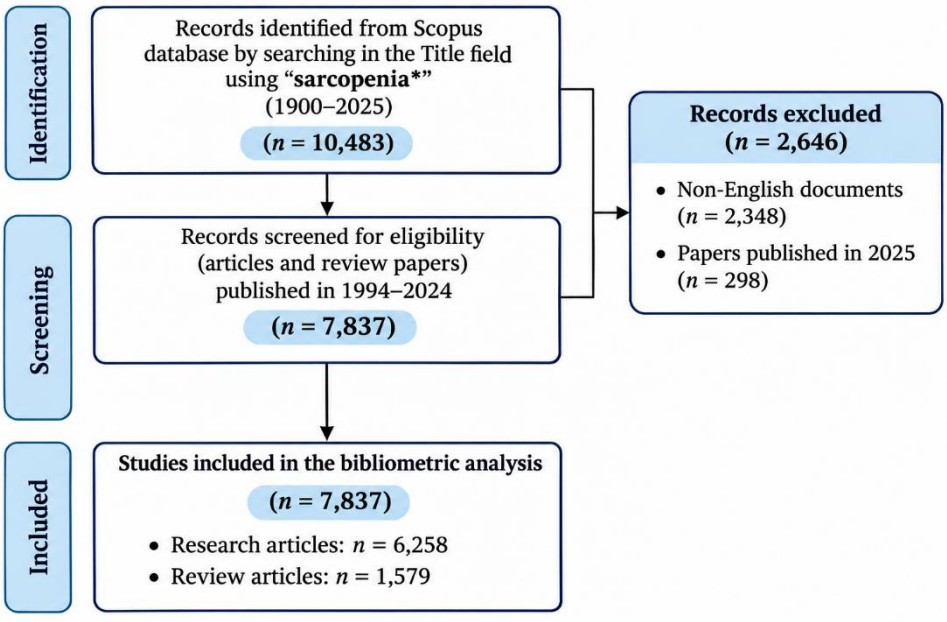


Figure 1. PRISMA flow diagram illustrating the identification, screening, and selection of Scopus-indexed publications on sarcopenia from 1994 to 2024.

Results and Discussion

Results

General characteristics of the bibliometric dataset and citation analysis

A total of 7,837 Scopus-indexed publications related to sarcopenia, published between 1994 and 2024, were identified in the bibliometric dataset. These publications were distributed across 1,754 scientific sources and accumulated 313,323 citations, corresponding to an average of 39.98 citations per document (Figure 2). Correlation analysis revealed a negligible positive relationship between the total number of publications (TNP) and the mean total citations per year ($r = 0.053$; reported $P > 0.005$), suggesting that annual publication volume was not strongly associated with the corresponding citation indicator. Temporal citation patterns showed notable peaks in 1998 and 2010 for both mean total citations per article (Mean TC Art) and mean total citations per year (Mean TC Year), as illustrated in Figures 2A and 2B. Meanwhile, annual scientific production increased substantially after 2010, indicating an expansion of research activity in the field of sarcopenia (Figure 2C).

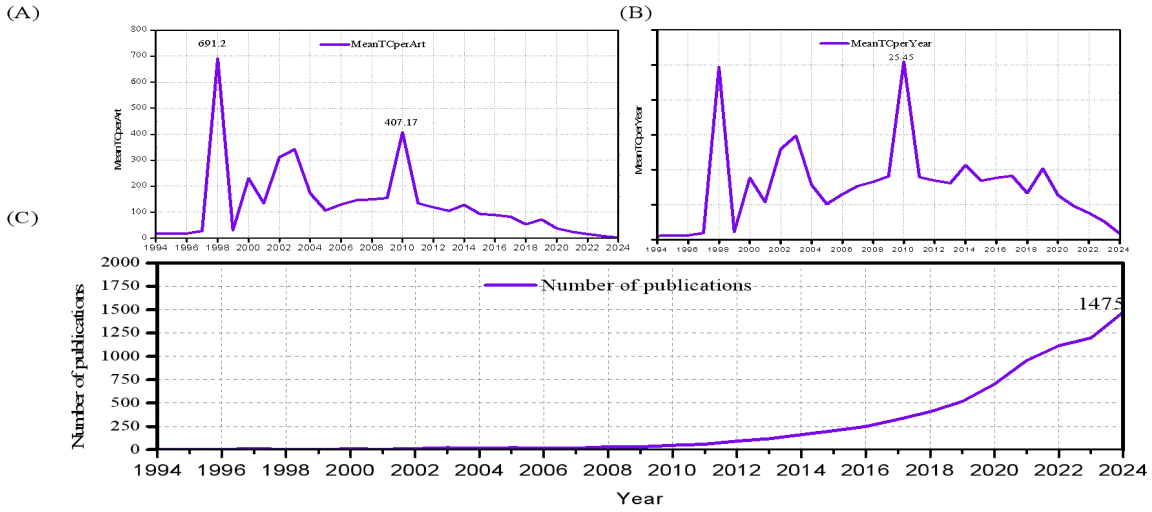


Figure 2. Temporal trends in sarcopenia research indexed in the Scopus database from 1994 to 2024: (A) mean total citations per article (Mean TC Art), (B) mean total citations per year (Mean TC Year), and (C) annual scientific production.

Author productivity and citation impact

A total of 28,852 authors contributed to the Scopus-indexed literature on sarcopenia during the study period (1994–2024), reflecting the broad participation of researchers in this field. Table 2 presents the ten leading authors based on bibliometric performance indicators, including the total number of publications (TNP), total number of citations (TNC), and h-index, together with their institutional affiliations and countries.

Among the authors listed, Landi F, affiliated with Università Cattolica del Sacro Cuore in Rome, Italy, demonstrated the highest publication output (104 publications), citation count (30,073 citations), and h-index (55). Marzetti E ranked second in publication productivity, contributing 83 publications, followed by Calvani R (69), Cesari M (68), and Sayer AA (67). However, publication productivity did not consistently correspond to citation performance. For example, Cesari M accumulated 16,527 citations from 68 publications, whereas Marzetti E recorded 6,828 citations from 83 publications. Similarly, Sayer AA and Cooper C accumulated 14,743 and 14,382 citations, respectively, despite having fewer publications than several other leading contributors.

Across the ten authors, citation counts ranged from 5,104 to 30,073, while h-index values ranged from 31 to 55. These variations indicate that publication volume, citation accumulation, and h-index represent related but distinct dimensions of bibliometric performance. Correlation analysis revealed a strong positive association between publication output and h-index ($r = 0.923$, $p < 0.0001$), suggesting that authors with higher publication productivity generally exhibited higher h-index values within the analysed group. Nevertheless, this relationship should be interpreted as an association rather than evidence that greater publication output directly determines citation impact.

The geographical distribution of the leading authors further highlights the contributions of established research institutions in Europe and the United States. Five of the ten authors were affiliated with institutions in Italy, three with institutions in the United Kingdom, and two with institutions in Belgium and the United States, respectively. Overall, these findings demonstrate differences in scientific productivity and citation performance among prominent contributors to sarcopenia research and underscore the importance of considering multiple bibliometric indicators when evaluating author-level research contributions.

Table 2. Leading Authors in Scopus-Indexed Sarcopenia Research (1994–2024)

Author	Country	h-index	TNC	TNP
Landi F	Italy	55	30,073	104
Marzetti E	United States	46	6,828	83
Cesari M	Italy	45	16,527	68
Bernabei R	Italy	39	6,315	52
Calvani R	Italy	39	5,104	69
Cooper C	United Kingdom	37	14,382	56
Reginster Jy	United Kingdom	34	13,490	60
Sayer Aa	United Kingdom	34	14,743	67
Beaudart C	Belgium	32	5,145	61
Bruyère O	Belgium	31	12,992	54

TNC = Total Number of Citations; TNP = Total Number of Publications. Values are reproduced from the supplied table. Institutional affiliations should be retained in the final manuscript after verification against the original bibliometric records.

Leading publication sources and bibliometric impact

A total of 1,754 publication sources contributed to the Scopus-indexed literature on sarcopenia between 1994 and 2024, reflecting the distribution of research across a wide range of scientific journals. Table 3 presents the leading publication sources and their bibliometric characteristics, including the total number of publications (TNP), total number of citations (TNC), h-index, 2023 Journal Impact Factor (JIF), and country of origin.

The Journal of Cachexia, Sarcopenia and Muscle and Nutrients recorded the highest publication output among the journals listed, each contributing 237 publications. However, their citation performance differed considerably. The Journal of Cachexia, Sarcopenia and Muscle accumulated 13,921 citations and achieved the highest h-index (62), whereas Nutrients received 8,053 citations and had an h-index of 45. The Journal of Nutrition, Health and Aging followed in publication volume, contributing 162 publications, with 8,081 citations and an h-index of 47.

Notably, the Journal of the American Medical Directors Association recorded the highest total citation count (19,569) despite publishing fewer sarcopenia-related documents (110) than several other leading journals. Its h-index of 58 was the second highest among the sources presented. Similarly, the Journals of Gerontology: Series A, Biological Sciences and Medical Sciences accumulated 10,692 citations from 94 publications, achieving an h-index of 50. These findings demonstrate that publication volume and citation performance do not necessarily follow identical patterns across journals.

The journals represented in Table 3 cover several interconnected research areas, including gerontology, clinical nutrition, muscle physiology, and multidisciplinary health sciences. Their distribution highlights the interdisciplinary nature of sarcopenia research and its relevance to ageing, nutritional status, functional decline, and clinical care. Differences in citation counts, h-index values, and journal-level impact factors further illustrate the importance of evaluating publication sources using multiple bibliometric indicators rather than relying exclusively on the number of published articles.

Overall, the findings indicate that sarcopenia research is disseminated through both specialised journals focusing on muscle health and ageing and broader journals addressing nutrition, clinical medicine, and multidisciplinary health research. The prominence of these publication sources provides insight into the disciplinary structure and scientific dissemination of sarcopenia-related research during the study period.

Table 3. Leading journals publishing scopus-indexed sarcopenia research (1994–2024)

Journal	h-index	TNC	TNP	JIF (2023)	Country
Journal of Cachexia, Sarcopenia and Muscle	62	13921	237	9.4	Germany
Journal of the American Medical Directors Association	58	19569	110	4.2	USA
Journals of Gerontology - Series A Biological Sciences and Medical Sciences	50	10692	94	4.3	USA
Journal of Nutrition, Health and Aging	47	8081	162	4.3	France
Nutrients	45	8053	237	4.8	Switzerland
Experimental Gerontology	41	5016	117	3.3	England
Clinical Nutrition	40	7578	101	6.6	Scotland
Plos One	39	5413	111	2.9	USA
Geriatrics and Gerontology International	37	4510	106	2.4	Japan

TNC = Total Number of Citations; TNP = Total Number of Publications; JIF = Journal Impact Factor; USA = United States of America. Values are reproduced from the supplied table and have not been independently verified.

Country-level scientific productivity, international collaboration, and citation impact

The geographical analysis identified contributions from 79 countries to Scopus-indexed sarcopenia research between 1994 and 2024. As presented in Table 4, China emerged as the leading country in terms of corresponding-author publication output, contributing 1,697 articles (21.7% of the country-attributed publications). Japan ranked second with 892 publications (11.4%), followed by the United States (689; 8.8%), South Korea (656; 8.4%), and Italy (443; 5.7%). These findings indicate substantial geographical variation in scientific productivity, with Asian countries accounting for several of the highest publication counts.

Analysis of international collaboration revealed differences between national publication output and the relative proportion of internationally co-authored research. China recorded the highest number of single-country publications (SCP = 1,529) and multiple-country publications (MCP = 168) among the countries listed. However, internationally co-authored publications represented only 9.9% of China's total output. In comparison, the United Kingdom demonstrated the highest MCP proportion (33.3%), followed by Spain (30.2%), Australia (29.9%), Brazil (28.0%), and Italy (27.8%). The United States recorded 134 internationally co-authored publications, representing 19.4% of its

output. These findings suggest that publication productivity and the relative prevalence of international collaboration represent distinct dimensions of national research activity.

Citation analysis revealed a different geographical distribution of research impact. The United States recorded the highest total number of citations (55,281), followed by China (35,090), Japan (26,975), Spain (26,343), and Italy (23,151). However, the average number of citations per article varied considerably across countries. Spain demonstrated the highest average article citation count (112.1), followed by Canada (102.4) and the United States (80.2). By contrast, China, despite contributing the largest number of corresponding-author publications, recorded an average of 20.7 citations per article. These differences highlight the importance of considering both publication volume and citation-based indicators when evaluating national contributions to sarcopenia research.

Overall, the findings demonstrate that countries leading in publication productivity do not necessarily exhibit the highest citation averages or international collaboration proportions. China's leading position in publication output contrasts with the higher citation totals recorded by the United States and the higher average citation counts observed in Spain and Canada. Similarly, the United Kingdom, Spain, and Australia exhibited comparatively high proportions of internationally co-authored publications despite contributing fewer publications than China and Japan. These patterns provide a multidimensional perspective on the geographical distribution of sarcopenia research and highlight differences in scientific productivity, citation performance, and international research connectivity.

Table 4. Country-level publication productivity, international collaboration, and citation performance in Scopus-indexed sarcopenia research (1994–2024)

Panel A. Leading countries by corresponding-author publication output

Country	Articles	Articles %	SCP	MCP	MCP %
China	1697	21.7	1,529	168	9.9
Japan	892	11.4	851	41	4.6
USA	689	8.8	555	134	19.4
Korea	656	8.4	597	59	9
Italy	443	5.7	320	123	27.8
Brazil	311	4	224	87	28
UK	279	3.6	186	93	33.3
Turkey	263	3.4	243	20	7.6
Spain	235	3	164	71	30.2
Australia	184	2.3	129	55	29.9

Panel B. Leading countries by total citations

Country	SCP	TNC	AAC
United States	1,529	55281	80.20
China	851	35090	20.70
Japan	555	26975	30.20
Spain	597	26343	112.10
Italy	320	23151	52.30
South Korea	224	16827	25.70
Canada	186	13827	102.40
United Kingdom	243	13751	49.30
France	164	8551	63.30
Australia	129	7687	41.80

SCP = Single Country Publications; MCP = Multiple Country Publications; TNC = Total Number of Citations; AAC = Average Article Citations. MCP (%) represents the proportion of multiple-country publications within each country's corresponding-author publication output. Values are reproduced from the supplied data.

Top 10 most cited articles analysis.

Table 5 presents the top-cited article by Cruz-Jentoft A.J. et al. (2010) entitled "Sarcopenia: European consensus on definition and diagnosis," which received much more attention among the scientific community and was cited 9172

times. The article was highlighted to boost recognition of Sarcopenia and its risk. It encourages healthcare specialists who manage individuals at risk for Sarcopenia to take actions that will support rapid detection and treatment to prevent or delay adverse health effects and overcome the unexpected burdens on healthcare systems[8]. Also, the article provides key characteristics of Sarcopenia, detection, and diagnosis, as well as identifies poor physical performance. The article "Sarcopenia: revised European Consensus on Definition and Diagnosis" is among the second-highest influential papers in the field, cited 8050 times[6].

The dominance of the EWGSOP[8], revised EWGSOP [6] and AWGS[27, 28] consensus papers among the most-cited works indicate that the establishment of standardised definitions and diagnostic criteria has been the central organising priority of the field. This is consistent with the thematic evolution observed in Figure 5: the earlier periods (1994–2018) are dominated by definitional and assessment-related themes (muscle mass, body composition, screening), whereas later periods show diversification toward biomarkers, mechanisms, and prediction methods. Read together, these findings suggest that once diagnostic consensus was achieved, research attention could shift toward understanding aetiology, identifying early biomarkers, and developing targeted interventions—a maturation pattern consistent with the trajectory of other clinical research fields. Read together, these findings suggest that once diagnostic consensus was achieved, research attention could shift toward understanding aetiology, identifying early biomarkers, and developing targeted interventions—a maturation pattern consistent with the trajectory of other clinical research fields[29] The coexistence of European and Asian consensus papers further suggests global convergence on diagnostic principles while highlighting regional differences in body composition and case-finding, an issue relevant to individualised management[30]

Collaboration network analysis

Figure 3 displays the collaboration network of contributing authors in global research productivity on sarcopenia articles, which includes 48 reported contributions organized into three distinct clusters. These clusters are based on Betweenness Centrality, highlighting key nodes that connect different parts of the network, and Closeness Centrality, which reflects the intersection of contributions between authors across various institutions. Cluster 1 includes twenty-nine authors: Zhang Y, Wang Y, Li Y, Liu Y, Wang X, Chen X, Zhang X, Wang J, Chen Y, Zhang L, Yang Y, Li J, Wang L, Wang Z, Li X, Liu X, Dong B, Zhang H, Zhang Q, Liu J, Wang H, Li H, Yue J, Chen J, Zhang J, Wu J, Yang M, Yang J, and Li Z. Cluster 2 includes 14 authors: Landi F, Marzetti E, Calvani R, Cesari M, Sayer AA, Beaudart C, Reginster JY, Cooper C, Bruyère O, Bernabei R, Cruz-Jentoft AJ, Picca A, Vellas B, and Rolland Y, and Cluster 3 includes five authors: Arai H, Kim M, Kim S, Won CW, and Chen IK (Figure 3A).

Collaboration network analysis between the institutions is displayed in the seven clusters. Cluster 1 includes 5 institutions: Taipei Medical University, National Taiwan University Hospital, National Taiwan University, China Medical University, and National Yang-Ming Chiao Tung University. Cluster 2 includes 5 institutions: the University of Alberta, the University of Florida, the University of California, Harvard Medical School, and the University of Pittsburgh. Cluster 3 includes 5 institutions: the University of Southampton, the University of Liège, Newcastle University, the University of Birmingham, and Maastricht University. Cluster 4 consists of 3 institutions: Kyung Hee University, Seoul National University College of Medicine, and Seoul National University. Cluster 5 includes 6 institutions: the University of Melbourne, Monash University, Deakin University, the University of Sydney, the National University of Singapore, and the University of Melbourne. Cluster 6 includes 4 institutions: the Chinese University of Hong Kong, the University of Tokyo, the National Center for Geriatrics and Gerontology, and Kyoto University, and Cluster 7 includes 2 institutions: Wenzhou Medical University and the First Affiliated Hospital of Wenzhou Medical University (Figure 3.B).

Collaboration network analysis between the countries is displayed in the seven distinguished clusters. Cluster 1 contains 38 countries: China, Japan, the USA, South Korea, Italy, the United Kingdom, Spain, Brazil, Australia, Turkey, France, Germany, the Netherlands, Canada, Belgium, Iran, Singapore, Sweden, Portugal, India, Switzerland, Denmark, Thailand, Poland, Greece, Mexico, Hong Kong, Chile, Austria, Ireland, Finland, Israel, the Czech Republic, Norway, Saudi Arabia, Colombia, New Zealand, Lithuania, Malaysia, Egypt, the United Arab Emirates, Pakistan, Argentina, and Lebanon. Cluster 2 includes only Malaysia. Cluster 3 includes Indonesia. Cluster 4 includes Egypt. Cluster 5 consists of the United Arab Emirates and Pakistan. Cluster 6 includes Argentina, and Cluster 7 includes Lebanon (Figure 3C).

Keywords analysis

The 10 most frequent authors' keywords (Figure 4A), Keywords Plus (Figure 4B), Title Words (Figure 4C), and Abstract Words (Figure 4D) were presented from data obtained from the Scopus database. The 10 most frequent authors' keywords (Figure 4A), Keywords Plus (Figure 4B), Title Words (Figure 4C), and Abstract Words (Figure 4D) were presented from data obtained from the Scopus database.

The Word Cloud for authors revealed that most scientific research focused on the authors' Keywords. It is frequency laid on topics including "sarcopenia" (5916), "ageing" (607), "frailty" (499), "muscle mass" (444), "muscle strength" (370), "older adults," (332), "skeletal muscle," (330), "Elderly" (323), and "body composition" (310) among others were the most frequent Authors Keywords contributors to sarcopenia research (Figure 4A).

The co-occurrence of "muscle mass," "muscle strength," and "frailty" should not be read as treating these constructs as interchangeable. Rather, their increasing co-occurrence likely reflects the field's adoption of multidimensional definitions in which mass, strength, and physical performance are distinct diagnostic domains [6, 8]. The growing frequency of "muscle strength" and "handgrip strength" relative to "muscle mass" alone is consistent with a shift toward functional assessment, in line with consensus recommendations that strength and performance, rather than mass alone, better predict adverse outcomes . This shift has direct clinical implications, favouring measures such as grip strength and gait speed in routine assessment.

The most frequent Keywords Plus included "sarcopenia" (15594), "aged" (9770), "male" (8082), "females" (6995), human" (6995), "Humans" (5441), "article," (4745), "middle-aged," (3945), "adult "(3609), "major clinical study" (3261) among others reported Keywords Plus indicating a strong focus on age-related muscle loss and its clinical implications (Figure4 B). Moreover, the frequency analysis of the top Title and Abstract words was displayed in Figures 4C and 4D.

Figure 5. Thematic Evolution of Authors' Keywords (A) and Keywords Plus (B)

Thematic evolution of authors' keywords

The keywords provided span various topics related to ageing, skeletal muscle health, and associated conditions. Based on the thematic analysis outcome of qualitative analysis, we found that the main research areas and focus with the global research productivity from data indexed in Scopus during 1994-2018 are the primary focus on "Age-related muscle loss, body composition, exercise and physical activity, postoperative complications, sarcopenia, and screening," and between 2019-2021 research we primary covers "aging, muscle mass, sarcopenia, prognosis, muscle mass, screening and oncology, particularly in the context of gastric cancer.

From the beginning of 2022 to the end of 2022, the research topics primarily focused on biomarkers (e.g., inflammatory markers, gut microbiota), body mass index (BMI), and the interplay between chronic diseases and aging. Key areas of interest include cardiovascular disorders, chronic obstructive pulmonary disease (COPD), and type 2 diabetes, as well as the application of advanced technologies like ultrasound and deep learning in geriatric medicine. The gut microbiota's role in health and disease, along with functional measures such as handgrip strength (HGS), is also a significant focus. Additionally, the research explores the influence of malnutrition, obesity, and osteoporosis on health consequences, especially in ageing populations.

In the years 2023 to the end of 2023, the research mainly highlighted the areas of "cystatin C, DM, HGS, mortality, sarcopenia, and skeletal muscle," recommending a research emphasis on the interplay between kidney function, DM, muscle health, and mortality, mainly in the setting of ageing and chronic disease.

From 2024 to the end of 2024, scientists have covered the " cystatin C as a biomarker of kidney function, older adults, Sarcopenia, Mendelian randomization, prognosis, aging, machine learning, myostatin as a therapeutic target for muscle wasting in older adults., and SARC-F Questionnaire as provide evidence that scholars have increasingly focused on the intersection of aging, Sarcopenia, and biomarkers such as cystatin C as a biomarker of kidney function and its role in aging-related conditions and myostatin, utilizing advanced methodologies like Mendelian randomization towards to explore causal associations in aging and Sarcopenia, and machine learning. It is important to distinguish genuinely emergent themes from those that have gained visibility. Cystatin C and myostatin, for example, have been investigated for over a decade but appear in the sarcopenia literature with increasing frequency only in recent periods, suggesting growing recognition rather than de novo emergence. In contrast, machine learning and Mendelian randomization represent methodologically newer entrants to the field. This distinction matters for interpreting Figure 5: the later periods do not necessarily reflect entirely new research questions, but rather the application of new methods and the ascendancy of previously marginal topics within the sarcopenia mainstream (Figure 5A).

Thematic evolution of keywords plus

Between 1994 and 2018, research primarily focused on age-related changes in muscle mass, and human studies related to aging research focused on retrospective studies, muscle mass measurement, and assessment. The results laid the foundation for current research on Sarcopenia and ageing, highlighting the worth of muscle health in preserving QOL and independence in older adults.

In 2019-2021, the research mainly focused on "Metabolism, retrospective study, Sarcopenia, and skeletal muscle. The study emphasized the significance of metabolic changes in maintaining skeletal muscle health and

function. It also explored retrospective analyses and Sarcopenia to deepen understanding of the mechanisms, diagnosis, and effects related to skeletal muscle.

Between 2022 and 2024, the scientific community placed significant emphasis on the themes of mouse models, muscle strength, and non-human studies to explore mechanisms of muscle health and disease; retrospective studies towards understanding relationships between muscle health, ageing, and disease outcomes; sarcopenia; skeletal muscle; major clinical studies; and muscle mass (Figure 5B).

Emerging trends of research in sarcopenia-related articles

Thematic Evolution of Keywords (Authors' Keywords and Keyword Plus)based on the prevalence degree (centrality) as the importance of a theme in connecting different research areas, and developmental degree (density) as the internal development of a theme) were presented in four thematic categories (Emerging or declining themes, which are identified as low centrality and low density; basic themes, high centrality and low density; motor themes, high centrality and high density; and Niche themes, low centrality and high density).

The thematic topics identified—cystatin C, myostatin, machine learning, and Mendelian randomisation—represent different aspects of sarcopenia research and can be organised into broader scientific categories (Table 6). Cystatin C and creatinine relate to diagnostic biomarker research; myostatin and skeletal muscle biology relate to biological mechanisms and therapeutic targets; machine learning and Mendelian randomisation represent emerging analytical methods. This categorisation clarifies that these themes are not independent but represent complementary layers of the same translational pathway—from risk identification (biomarkers) through mechanistic understanding (myostatin, muscle biology) to intervention (therapeutic targets)—enabled by new analytical approaches.

These themes are not independent. The convergence of biomarker research (cystatin C), prediction methods (machine learning), and causal-inference approaches (Mendelian randomisation) reflects a shared objective: earlier and more accurate identification of individuals at risk, and clarification of causal pathways. Similarly, myostatin research represents a shift toward mechanism-based therapeutic development. Viewed this way, the thematic evolution describes a coordinated movement along the translational continuum rather than a disparate collection of topics.

Key themes and trends in sarcopenia

Keyword analysis reported that the authors' keywords highlighted that keywords plus "Sarcopenia, fatality, and muscle mass have had strong internal development, indicating their importance in both research and clinical practice in understanding age-related muscle loss and its clinical implications. The author's Keywords within the four-time scales include Cystatin C, Creatinine, older patients, DM, and stroke. These represent well-established and influential areas in sarcopenia research and indicate their importance in research and clinical practice (Figure S1). Keyword Plus, across the four scales, the topic encompasses "humans, sarcopenia, muscle strength, HGS, and cross-sectional study." These keywords are essential in research and clinical practice (Figure 2S).

Discussion

Taken together, the citation and thematic analyses suggest that sarcopenia research is undergoing a conceptual transition. The highly cited core of the literature is dominated by consensus definitions and diagnostic criteria, reflecting the field's first priority: establishing what sarcopenia is and how it should be measured. The thematic evolution, however, reveals a second phase: growing attention to biological mechanisms (myostatin, muscle biology), early detection (cystatin C, SARC-F), and prediction and causal inference (machine learning, Mendelian randomization). This trajectory—from definition to mechanism to targeted management—parallels the development of other chronic disease fields and suggests that sarcopenia research is maturing from nosology toward translational science. The extent to which these emerging themes translate into clinical benefit will depend on validation across populations and settings, as discussed below

The previous investigation reveals that no bibliometric analysis in health research has been conducted to comprehensively analyse numerous citations, authors' contributions, countries or regions, keywords, and publications. To fill this gap, this current study aims to explore the global research productivity on sarcopenia documents indexed in Scopus, as in other previous studies[14, 23, 31-33].

This study illustrated that the global research productivity on sarcopenia documents received 313,323 citations, averaging 39.98 per document. Compared to other published health research fields, childhood obesity[14], infectious diseases [31, 32], and malnutrition [34]. The higher number of citations related to Sarcopenia may be attributed to its increasing prevalence and impact on populations, as it represents the progressive decline in muscle mass and function associated with ageing [28] that influences higher mortality rates and a raised incidence of falls and hospital admissions, particularly among older adults [28].

This first comprehensive study provides the scientific productivity trend of publications, sources, citation times, and Authorship analysis. The findings show the International co-authorships between countries, authors, and

institutions [14] [22, 31, 32, 34]. The study shows increased citations in recent years, indicating that the reported articles were the most influential among scholars globally. Also, the articles published by Cruz-Jentoft A.J. et al. (2010 received higher citations. They covered fundamental issues related to the definition of sarcopenia and diagnosis strategies, so it is considered a profound novelty for supporting essential information for those in the field[5]. Recently published articles indicate that Sarcopenia is still a new challenge for clinical practice[35]. Thus, understanding and designing a clinical diagnosis and care for people with sarcopenia [6]. Most of the reported countries that contributed to global research productivity on Sarcopenia were China and the United States institutions, which produced more articles than any other country. The reason behind this may be that China and the United States have more funding to support research productivity than other countries[14, 23].

The journal's qualitative analysis noted that the most prolific journal-published articles were mainly associated with the fields, as reported in previous studies[16]. Moreover, it was observed that close collaborations between authors' countries were limited, including those among researchers from China, Japan, the USA, South Korea, Italy, the United Kingdom, Spain, Brazil, Australia, Turkey, and France. Conversely, many scholars assert that the citation of articles or journals plays a crucial role in reflecting the impact of a publication within global research communities and the interconnectedness between scientific works [27]. For many years, citation analysis has remained a key method for evaluating journals in scientific research. Following a thorough co-occurrence analysis of authors' keywords, it was observed that the primary research directions in the sarcopenia field largely centre around "sarcopenia," "ageing," "frailty," "muscle mass," "muscle strength," "older adults," "skeletal muscle," "elderly," and "body composition," among other topics. Based on their reported frequency over the past year, these keywords were identified as the most frequent contributors to sarcopenia research.

The distribution of publications across geriatrics (JAMDA, Journals of Gerontology), nutrition (Journal of Nutrition, Health and Aging; Nutrition; Clinical Nutrition), muscle biology (Journal of Cachexia, Sarcopenia and Muscle), and general medicine (PLOS One) indicates that sarcopenia is approached from multiple disciplinary perspectives. The prominence of nutrition and geriatric journals suggests that sarcopenia remains anchored in aging-related and nutritional science, while the strong position of the Journal of Cachexia, Sarcopenia and Muscle reflects the integration of muscle biology and cachexia research. Notably, the presence of general and multidisciplinary journals (e.g., PLOS One) suggests widening interest beyond specialist geriatric audiences. However, the relative absence of cardiology, oncology, and rehabilitation journals from the top ranks may indicate that integration with other clinical specialties is still developing—an important direction for future research [36].

The prominence of the European and Asian consensus papers [6, 8] among the most-cited works indicates that establishing agreed diagnostic definitions and assessment criteria has been the central organising priority of the field. This pattern suggests that sarcopenia research has followed a maturation trajectory common to other clinical fields: consensus definition precedes aetiological investigation, which in turn enables targeted intervention[29]. The field now appears to be moving beyond diagnostic standardisation toward questions of treatment effectiveness, long-term outcomes, and individualised management—as reflected in the growing thematic emphasis on biomarkers, prediction models, and mechanism-based therapeutics

It is important to distinguish research prominence from clinical readiness. Cystatin C is an established marker of kidney function, but its role as a sarcopenia biomarker requires validation against reference standards (e.g., DXA or bioimpedance), demonstration of incremental value over existing measures, and establishment of clinically meaningful thresholds[37]. Machine-learning models require external validation across diverse populations, transparent reporting, and prospective evaluation before deployment. Myostatin inhibition has shown promise in preclinical and early-phase studies, but confirmatory trials with functional endpoints are needed. Thus, the emerging themes identified here represent research frontiers rather than ready-for-practice tools; their translation will depend on rigorous validation and evidence generation[38]

Our findings both confirm and extend previous bibliometric work. Consistent with Yuan et al. (2), we observed exponential growth in publications after 2010 and the dominance of China and the USA in output [2]. However, our longer time frame and thematic-evolution approach reveal developments not captured in earlier analyses: the emergence of biomarker-driven research, the adoption of machine learning and Mendelian randomisation, and the growing emphasis on functional assessment. In contrast to Mohammed and Li [21] , which focused on the sarcopenia–cancer intersection, the present study maps the broader conceptual evolution of the field and situates cancer-related muscle loss within a wider translational trajectory. Unlike previous analyses that reported thematic trends as static lists, the present study distinguishes genuinely emergent themes from those gaining visibility and links them to the field's conceptual maturation.

The co-occurrence of 'muscle mass,' 'muscle strength,' and 'frailty' should not be read as treating these constructs as interchangeable. Rather, their increasing co-occurrence likely reflects the field's adoption of multidimensional definitions in which mass, strength, and physical performance are distinct diagnostic domains [6, 8] .

The growing frequency of 'muscle strength' and 'handgrip strength' relative to 'muscle mass' alone is consistent with a shift toward functional assessment, in line with consensus recommendations that strength and performance, rather than mass alone, better predict adverse outcomes. This shift has direct clinical implications, favouring measures such as grip strength and gait speed in routine assessment

In the analysis of co-authorship visualisation networks, there is clear evidence of authorship collaboration between groups of authors and authorship within different reported countries. The higher the linkage strength between authors or countries, the more closely authors or countries collaborate with other countries, as reported in global research in the Sarcopenia-related field [2].

While Scopus databases, renowned for their historical author-affiliation records, were utilized for this bibliometric analysis, certain restrictions must be acknowledged. The study was restricted to articles written in English, potentially excluding those in other languages. Additionally, the analysis may have been affected by false-positive and false-negative results. It is also crucial to highlight that the research relied on open-source data, with new studies continually being published, which could influence the total citation counts and h-index values. Furthermore, older publications accumulate more citations, potentially introducing bias in evaluating the most-cited works. Despite these limitations, the identified patterns and trends provide valuable insights for researchers aiming to enhance global productivity in sarcopenia-related studies.

Future research on sarcopenia should prioritise the translation of emerging scientific findings into clinically applicable diagnostic, prognostic, and therapeutic strategies. Particular attention should be directed toward validating cystatin C and other candidate biomarkers to determine their incremental predictive value beyond established measures of muscle strength, physical performance, and muscle mass, while identifying clinically meaningful diagnostic and prognostic thresholds. In parallel, machine-learning-based prediction models require rigorous external validation across geographically and ethnically diverse populations, with emphasis on predictive accuracy, calibration, generalisability, and algorithmic fairness. Further investigations employing Mendelian randomisation and longitudinal study designs are warranted to clarify potential causal relationships between sarcopenia and metabolic, renal, and cardiovascular outcomes. From a therapeutic perspective, emerging molecular targets, particularly myostatin-related pathways, should be investigated through well-designed and adequately powered clinical trials incorporating functional outcomes, physical performance, and patient-reported measures. Additionally, the clinical utility of SARC-F should be evaluated in routine primary care settings, particularly its feasibility, diagnostic performance, and integration with objective assessments of muscle strength and physical function. Strengthening international research collaboration through multicentre consortia, harmonised assessment protocols, and shared data infrastructures will also be essential to improving the reproducibility and generalisability of findings, particularly in underrepresented populations and regions. Collectively, these research priorities may facilitate the transition from descriptive and exploratory investigations toward more robust, clinically validated approaches to the early identification, risk stratification, prevention, and personalised management of sarcopenia.

Conclusion

This analysis shows that sarcopenia research has moved beyond its foundational phase of definition and diagnostic standardization. While consensus criteria remain the most-cited core of the literature, thematic evolution reveals a clear reorientation toward biological mechanisms, early detection through biomarkers, and prediction and causal inference using machine learning and Mendelian randomisation. These developments indicate that the field is increasingly concerned not only with identifying sarcopenia but with understanding why it develops and how it can be prevented or treated. Realising this potential will require validation of candidate biomarkers and prediction models across populations, translation of mechanistic targets into clinical trials, and sustained international collaboration. The present findings provide a map of where the field has been and where it appears to be heading, offering a foundation for targeted future investigations.

Acknowledgement

The authors would like to express their sincere gratitude to all individuals and institutions who provided support during the preparation of this review. The authors also acknowledge the valuable contributions of colleagues and reviewers whose insights and constructive feedback helped improve the quality of this manuscript.

Declarations

Author contribution: M.M. and M.E. conceptualised the review topic, designed the review framework, developed the search strategy, and supervised the overall study process. M.M .and M.E. also conducted the literature

search, screened the identified studies, interpreted the findings, and prepared the original manuscript draft. T.H.M. contributed to data curation, assisted in study screening and data extraction, critically reviewed the included literature, and contributed to the interpretation and synthesis of the findings. T.H.M. also performed critical revision and editing of the manuscript for important intellectual content. Both authors reviewed, revised, and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Funding statement: This research received no external funding. No specific grant was obtained from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
The authors further declare that there are no conflicts of interest regarding the publication of this manuscript.

Ethics Declaration: Ethical approval and informed consent were not required because this study is a narrative review based exclusively on previously published literature and did not involve human participants, animals, or the use of identifiable personal data.

Additional information: The authors confirm that all relevant data and information supporting the findings of this review are included within the manuscript and the cited references. The authors are solely responsible for the content and interpretation presented in this review.

Informed Consent Statement

Not applicable.This study did not involve human participants or the collection of identifiable personal information.

Data Availability Statement

Data were generated and analysed in this study using the R program. All information presented in this review was derived from previously published studies, which are cited appropriately throughout the manuscript.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process.

During the preparation of this manuscript, the authors used generative artificial intelligence (AI) tools solely to improve the language, grammar, and readability of the manuscript. All AI-assisted outputs were carefully reviewed, revised, and validated by the authors. The authors take full responsibility for the accuracy, integrity, and originality of the content presented in this article. No AI tools were used for study design, data collection, data analysis, interpretation of findings, or the formulation of scientific conclusions.

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