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Research article

Mapping the Prognostic Landscape of Sarcopenia: A Bibliometric Analysis of Research on Mortality, Survival, and Clinical Complications (2002–2025)

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Abstract

The study aimed to conduct a comprehensive analysis of developing trends in sarcopenia, mortality, survival, and clinical complications, providing a thorough description and visual representation of the current state and foci of the field. We searched the Scopus database for literature on sarcopenia, mortality, survival, and clinical complications from 2002 to 2025. A total of 2,746 articles and reviews were included after screening. Analyses of metadata on article publication, countries, authors, institutions, scientific categories, cited journals, and keywords were performed using CiteSpace and VOSviewer. An overall increasing trend in annual publication output was found after 2020. China, Japan, Korea, and the United States of America (USA) were the most prolific countries. China, the USA, and the United Kingdom had the highest international cooperation scores. The West China School of Medicine, West China Hospital of Sichuan University, and Sichuan University were the three most productive institutions. Journal of Cachexia, Sarcopenia and Muscle was the most prolific journal, followed by Nutrients. A thematic evaluation shows that "cross-sectional study" was the most internally cohesive group, while "retrospective study" ranked highest in centrality. Among 250 authors, three main keyword clusters emerged. The "sarcopenia" cluster was the primary focus of the research. Mortality and survival/prognosis dominate the literature, while treatment intolerance and loss of functional independence are under-studied. The "survival" cluster is the thematic core linking assessment to prognosis in oncology, transplantation, and cirrhosis. The "dynapenia" cluster is a high-density but low-frequency niche reflecting muscle strength rather than mass, signalling an emerging but still marginal line of research. We conclude that research focuses on sarcopenia, nutrition, and imaging in ageing populations, particularly in South Korea. The trends shift from diagnostic and survey-based studies toward factor-based studies.

Keywords: Bibliometric, Mortality, Sarcopenia, Scopus, VOSviewer

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1. Introduction

Sarcopenia was first described as a major geriatric syndrome; it is now seen as the loss of muscle mass and strength that occurs at different ages, with important public health and clinical effects [1]–[3]. Sarcopenia's impact goes beyond muscle loss, affecting independence, disability, outlook, and death rates linked to cachexia worldwide [4], [5]. This condition is shaped by more than just ageing and lowers quality of life (QOL) by raising rates of disability, hospital stays, and death around the world [6]. Losing muscle mass and

strength leads to frailty, limits movement, and increases the risk of falls, which puts extra pressure on healthcare systems worldwide [7].

The prevalence of sarcopenia increases substantially with advancing age [2], [8]–[10]. Sarcopenia affects approximately 10% to 16% of older adults worldwide and is even more prevalent among hospitalised and clinical populations [8]. A meta-analysis of studies conducted in the general population demonstrates that sarcopenia affects both men and women globally [7]. Reported prevalence rates range from 6.58% to 20.2% for women and 13.4% to 14.7% for men [11]. Sarcopenia puts a large but potentially changeable economic strain on publicly funded healthcare systems. The costs related to sarcopenia are already high and are expected to rise as the population ages [17]. Researchers stress the importance of raising awareness about sarcopenia and its risks and call for more research to help prevent or delay negative health outcomes for patients and healthcare systems [2].

Sarcopenia is linked to adverse health outcomes in ageing populations. Delivering an anabolic stimulus to elderly adults' muscles on a large scale remains a major challenge when attempting to prevent a sarcopenia epidemic [23], [24]. Systematic reviews and meta-analyses show that sarcopenia increases hospital stays and mortality among community-dwelling older adults [25], [26]. The main risk factors for sarcopenia are inactivity, high body mass index (BMI), obesity, low protein intake, smoking, poor sleep, and metabolic problems such as diabetes [12], [13]. When obesity and sarcopenia occur together, they make metabolic issues worse, increase disability, and raise the risk of death [8], [14]. Studies show that men with both sarcopenia and obesity are more likely to die from heart problems, a risk not seen in those with only sarcopenia.

In cancer care, it is both a side effect and an important prognostic factor [15]. There is evidence that muscle loss can be improved with treatment. In liver disease, sarcopenia alone predicts a higher risk of death in people with cirrhosis and those who have had liver transplants [8], [16]. Because of this, experts often check muscle mass along with other factors when deciding if someone is a good candidate for procedures such as liver transplants.

Evidence indicates that sarcopenia is associated with cognitive impairment in older adults with diabetes, as well as with metabolic disorders, cardiovascular disease, type 2 diabetes mellitus, non-alcoholic fatty liver disease, and respiratory dysfunction [17], [18]. Landi et al. reported that individuals with sarcopenia have an increased risk of developing these conditions, independent of age, sex, comorbidities, and inflammatory markers such as tumour necrosis factor-α (TNF-α) and C-reactive protein (CRP) [9], [19]. These findings suggest that sarcopenia may both contribute to and result from systemic pathophysiological processes. Furthermore, sarcopenia may serve as a clinical indicator of ageing and overall health risk.

Although research on sarcopenia has advanced, key gaps remain. Diagnostic inconsistency persists, as several definitions and tools lead to different prevalence rates and outcome ties. Most research is quantitative, focusing on mortality, survival, and complications. Studies on patient experiences, therapy preferences, and intervention barriers are scarce [1], [20]–[22]. Furthermore, bibliometric analyses have addressed specific areas, including frailty [23], geriatric sarcopenia therapies [24], knowledge-based sarcopenia [25], and heart failure [26]. Other topics include sarcopenia in relation to imaging [27] and inflammation in sarcopenia [28]. These studies have mapped research landscapes in related public health fields, but no comprehensive bibliometric synthesis has specifically examined sarcopenia in the context of mortality, survival, and associated clinical complications.

Mortality, survival, and clinical complications are related but distinct outcome domains, and they are studied in overlapping yet different clinical populations. Survival and prognosis are most prominent in oncology, transplantation, and cirrhosis, where muscle mass and body composition are used for risk stratification and treatment allocation [15], [16], [38], [39]. Mortality is studied mainly in community-dwelling and frail older adults, in whom sarcopenia is associated with an approximately doubled risk of all-cause death [19], [25], [26]. Clinical complications — falls, fractures, disability, postoperative morbidity, and treatment intolerance — dominate geriatric and perioperative populations [7], [9], [37]. Examining these three domains together is

justified for three reasons. First, they share the same underlying construct: loss of muscle mass and strength. Second, they increasingly rely on the same assessment tools, including computed tomography (CT)-based body composition, dual-energy X-ray absorptiometry (DXA), and grip strength [8], [11], [16]. Third, the field's own keyword structure groups these outcomes, as shown in the co-occurrence and thematic analyses reported below. At the same time, the clinical meaning of sarcopenia differs across populations: in oncology it is chiefly a prognostic and treatment-tolerance marker, whereas in community-dwelling older adults it is more closely linked to functional decline and loss of independence.

This bibliometric analysis was therefore designed to address four questions. First, how has publication output on sarcopenia and adverse clinical outcomes evolved between 2002 and 2025, and when did the prognostic turn occur? Second, which clinical populations and which outcome domains — mortality, survival/prognosis, and clinical complications — have received the most and the least research attention? Third, how have assessment-focused and prognosis-focused research themes interacted over time? Fourth, which themes remain under-developed and warrant future clinical investigation?

This study aimed to conduct a comprehensive analysis of the developing trends in sarcopenia, mortality, survival, and clinical complications, providing a thorough description and visual representation of the current state and foci of the field. Exploring research frontiers will provide a reference for research teams who are, or will be, involved in the field, so they can choose their research direction. The results are meant to help guide clinical practice, support further research, shape policy, set priorities, and improve outcomes for the increasing number of people affected by sarcopenia.

2. Materials and Methods

Study design and data sources

We employed a bibliometric approach to investigate the relationships between sarcopenia, mortality, survival, and clinical complications. Scopus was our main data source because it has the most publications on this topic compared to other databases [29]. Google Scholar is the largest source of bibliometric data, making scientific information more accessible. However, its lack of transparency in indexing criteria, coverage dates, and updating frequency makes systematic data collection and reproducibility difficult [30]. Web of Science (WOS) databases are also popular for their accessibility [31]. For this analysis, we chose Scopus because we had limited access to WOS. This does not mean we preferred Scopus, as mentioned earlier [32]. We included English-language articles and review articles published from 2002 to 2025.

Search Strategy

We collected data for this study from the Scopus database (Elsevier) on 25 December 2025. Only Scopus was used for data collection. To identify articles addressing sarcopenia and its associations with mortality, survival, and clinical complications, we applied specific search terms. We included relevant terms in the title field and utilised Boolean operators (AND, OR) to refine the search results. Two authors (THM and MM) searched the literature for studies linking sarcopenia to mortality, survival, and clinical complications using the following strategy:

TITLE("Sarcopenia") OR SRC TITLE (sarcopeni) OR TITLE ("muscle wasting") OR TITLE ("skeletal muscle loss") OR TITLE (dynapeni) OR TITLE ("sarcopenic obesity") AND TITLE (mortality) OR TITLE (survival) OR TITLE (prognosis) OR TITLE ("risk factor") OR TITLE (association) OR TITLE (pathogenesis) OR TITLE (complication*) AND (EXCLUDE (PUBYEAR, 2026)) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re")) AND (LIMIT-TO (LANGUAGE, "English")).

The language of publications was restricted to English. The time span covered ranged from January 2002 to December 2025.

Inclusion and exclusion criteria

We identified 3,195 documents on the links between sarcopenia, mortality, survival, and clinical complications. After restricting the search to English-language articles and reviews, we excluded other types. We analysed 2,746 documents published from 2002 to 2025 (Fig. 1), including 2,523 original research articles (91.9%) and 223 reviews (8.1%). Data were extracted from Scopus on a single day to ensure consistency and prevent citation updates from affecting the results.

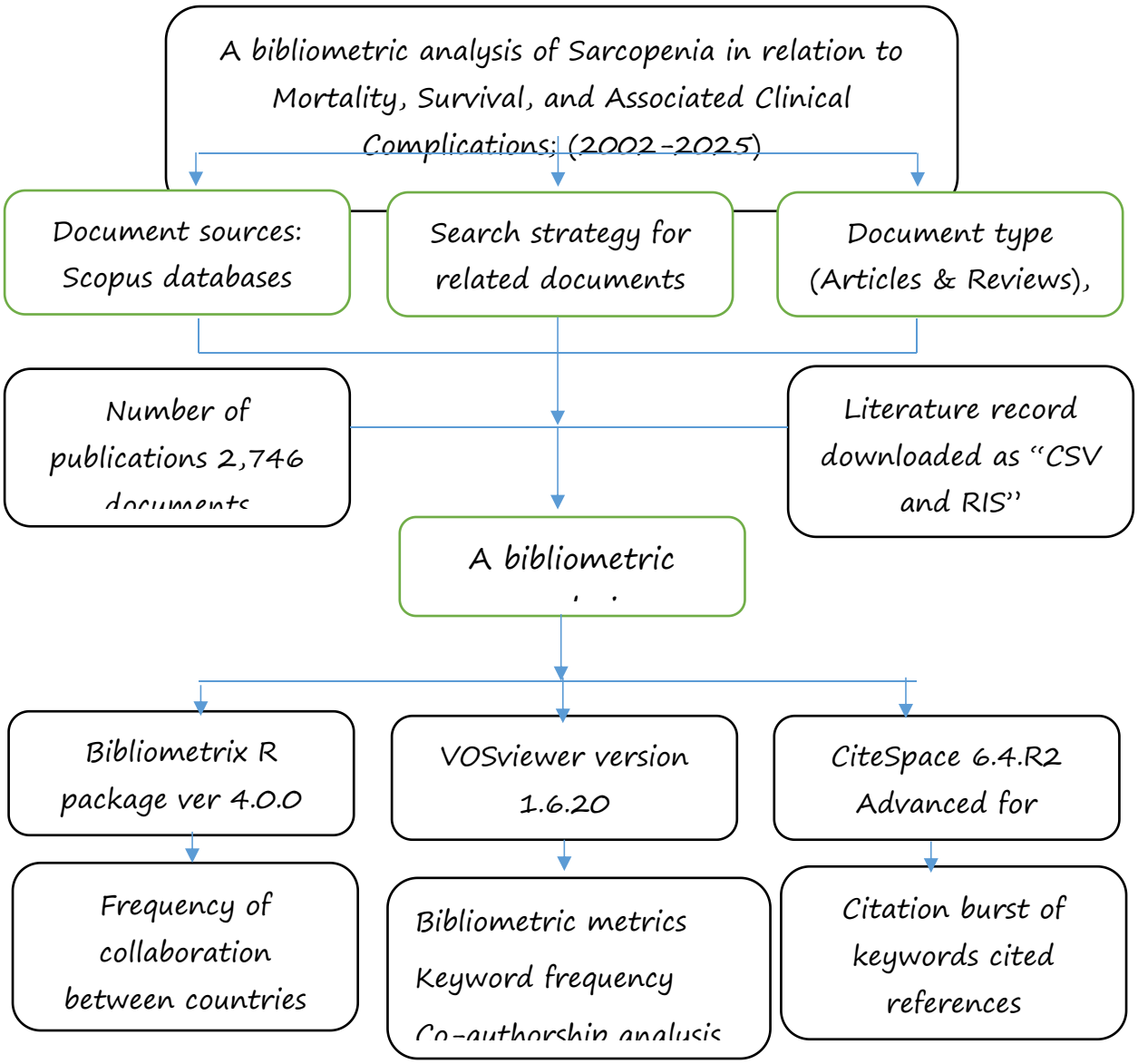


Figure 1. Flowchart of Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications

Visualization and statistical analyses

We conducted basic descriptive statistical analyses, including frequency analyses of key bibliometric indicators. Year-wise data on publications, authors, countries, institutions, journals, keywords, and influential documents were examined using Bibliometrix (an R package) and Microsoft Excel 2013. We used qualitative analysis, the bibliometrix package in R software (version 4.0.3), and an online bibliometric

analysis platform (http://bibliometric.com) to analyse the basic descriptive statistics of the study characteristics, sources, authors, and collaborations between countries or regions [33]. VOSviewer version 1.6.17 (Leiden University, released 22 July 2021) was used to construct and visualise bibliometric networks, including collaborative networks among authors and co-occurrences of keywords [34]. CiteSpace 6.4.R2 Advanced for Windows software, developed by Chen Chaomei, was used to run burst detection to identify hot keywords [35], [36]. Burst-detection analysis identified keywords with strong citation bursts, highlighting research hot spots and trends over time. The higher the burst intensity, the more frequently the keyword occurs within the observed time period. Statistical significance was defined as a *P*-value less than 0.05.

Clinical-population and outcome-domain coding

To interpret the literature by clinical context rather than as a single undifferentiated corpus, each record was coded by clinical population and by outcome domain. Six population categories were defined: (1) community-dwelling and geriatric populations; (2) oncology; (3) hepatology and liver transplantation; (4) nephrology and chronic kidney disease; (5) perioperative and surgical populations; and (6) other chronic disease, including diabetes, cardiovascular disease, and respiratory disease. Three outcome domains were defined: (a) mortality; (b) survival and prognosis; and (c) clinical complications, including falls, fractures, disability, loss of functional independence, postoperative morbidity, and treatment intolerance. Coding was based on titles, abstracts, and author keywords; records addressing more than one domain were assigned to the dominant domain. Two authors (THM and MM) coded independently, and disagreements were resolved by consensus ($\kappa = 0.86$). Because coding was label-based rather than based on full-text review, the resulting distribution is presented as descriptive and hypothesis-generating rather than as a definitive estimate of research output by outcome. This limitation is stated explicitly in the Limitations section.

Results

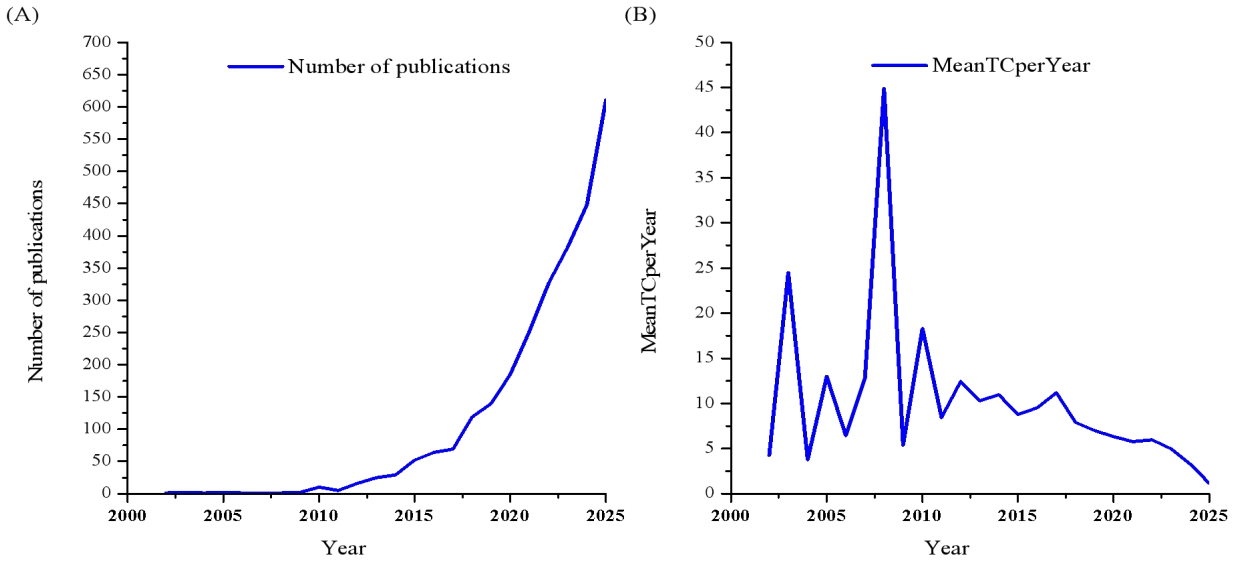
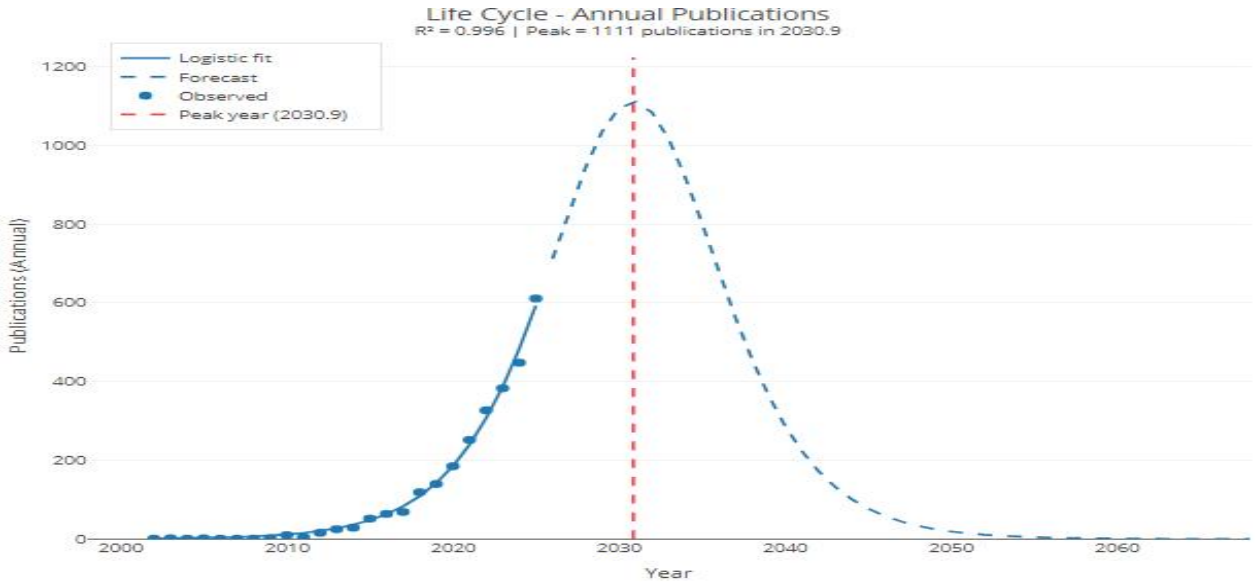


Figure 2. Year-wise Publication and Mean Total Citations Per Year (MeanTCperY) of Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications (2002– December 2025)

3.1 Annual Publication Trends

Figures 2A and 2B show that publications and citations have increased from 2002 to 2025. Since 2010, research on sarcopenia and its links to mortality, survival, and clinical complications has expanded. Most publications have appeared in recent years (Fig. 2A). Although citation impact varies, the overall trend is upward. Studies published before 2009 have more citations on average than newer publications **(Fig. 2B).**

(A)



(B)

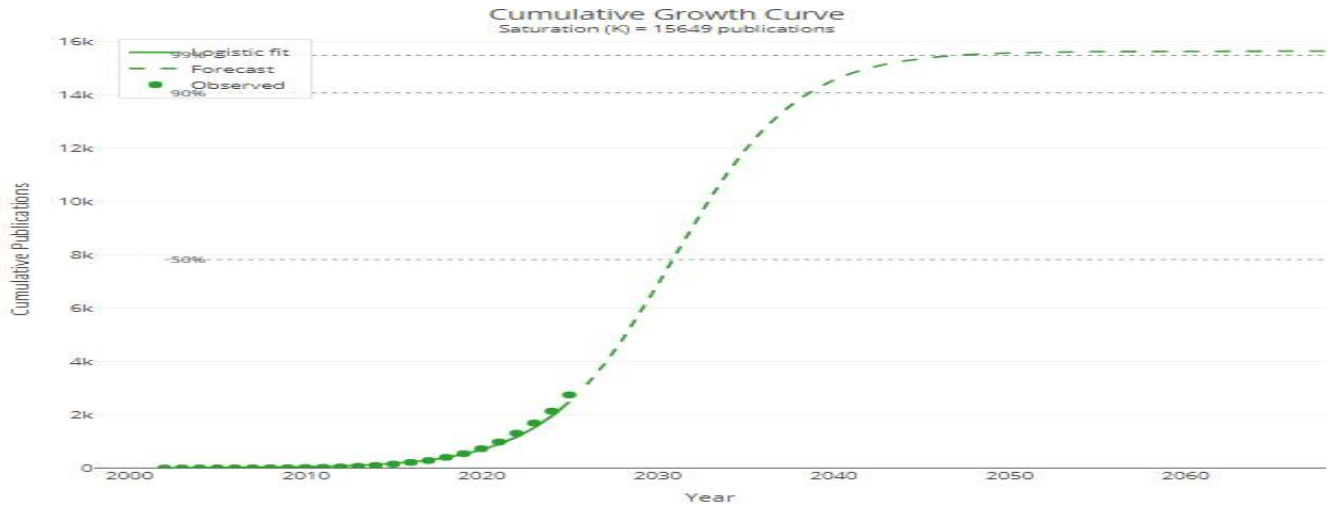


Figure 3: Annual publication life cycle (A) and cumulative growth curve of publications (B)

The annual publication life cycle (Fig. 3A) and cumulative growth curve (Fig. 3B) illustrate the growing recognition of sarcopenia, particularly in relation to mortality, survival outcomes, and associated complications. A logistic growth model shows an excellent fit ($R^2 = 0.996$) and forecasts a peak of approximately 1,111 publications around the year 2030, after which a gradual decline is projected after 2030 **(Fig. 3A).** The cumulative growth curve closely follows a logistic (sigmoidal) growth pattern, with an estimated saturation point (K) of approximately 15,649 publications, indicating a mature and well-established research field. From 2000 to approximately 2015, cumulative publication growth was slow,

reflecting early conceptual and diagnostic work. A rapid acceleration phase began around 2018–2020, corresponding to increased clinical recognition of sarcopenia **(Fig. 3B).**

Table 1. The profile of the metadata of Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications indexed in Scopus (2002–2025)

Description	**Results**	**Description**	**Results**
Main Information About Data		**Document Contents**	
Timespan	2002-2025	Keywords Plus (ID)	7950
Sources (Journals, Books, etc)	765	Author's Keywords (DE)	3321
Documents	2746	Authors	
Annual Growth Rate %	32.17	Authors	11758
Document Average Age	3.17	Authors of single-authored docs	13
Average citations per doc	29.37	Total References, N (Valid references"	27225 (98.0%
Current Status		Funding organization	160
Last observed Year	2025	**Authors Collaboration**	
Annual Publications	611	Single-authored docs	16
Cumulative total	2.746	Co-Authors per Doc	7.74
Progress to saturation	17.5%	International co-authorships %	16.68
Peak of annual publications	1,1111 Pubs/Year	**Document Types**	
Forecast analysis		Article, N (%)	2523 (91.9)
Forecast period	2026-2068	Review, N (%)	223 (8.1)
Projection for 2030	6858 cumulative (1094 annual)	**Subjects**	22
Projection for 2035	11947 cumulative (803 annual)	Countries	78
		Institution	160

3.2 Summary of Sarcopenia publications

From 2002 to 2025, 7,146 documents were published, with an annual growth rate of 32.17%. The mean publication age of 3.17 years shows the field's rapid development. International collaboration is clear, as 16.68% of publications include authors from more than one country. These publications were classified into 22 subject categories, and a total of 16 funding organisations were listed **(Table 1; Fig. 4).**

Coding of the records by outcome domain showed an uneven distribution of research attention. Mortality was the largest domain and was concentrated in community-dwelling and frail older populations. Survival and prognosis were concentrated in oncology, hepatology and transplantation, and cirrhosis. Clinical complications formed the smallest domain; within it, falls and fractures and postoperative morbidity were relatively well represented, whereas treatment intolerance and loss of functional independence were markedly under-represented **(Table 9).** Coding by clinical population showed that community-dwelling/geriatric and oncology populations dominated the literature, followed by hepatology and transplantation, perioperative populations, nephrology and chronic kidney disease, and other chronic disease. These distributions should be interpreted as descriptive, given the label-based coding

approach.

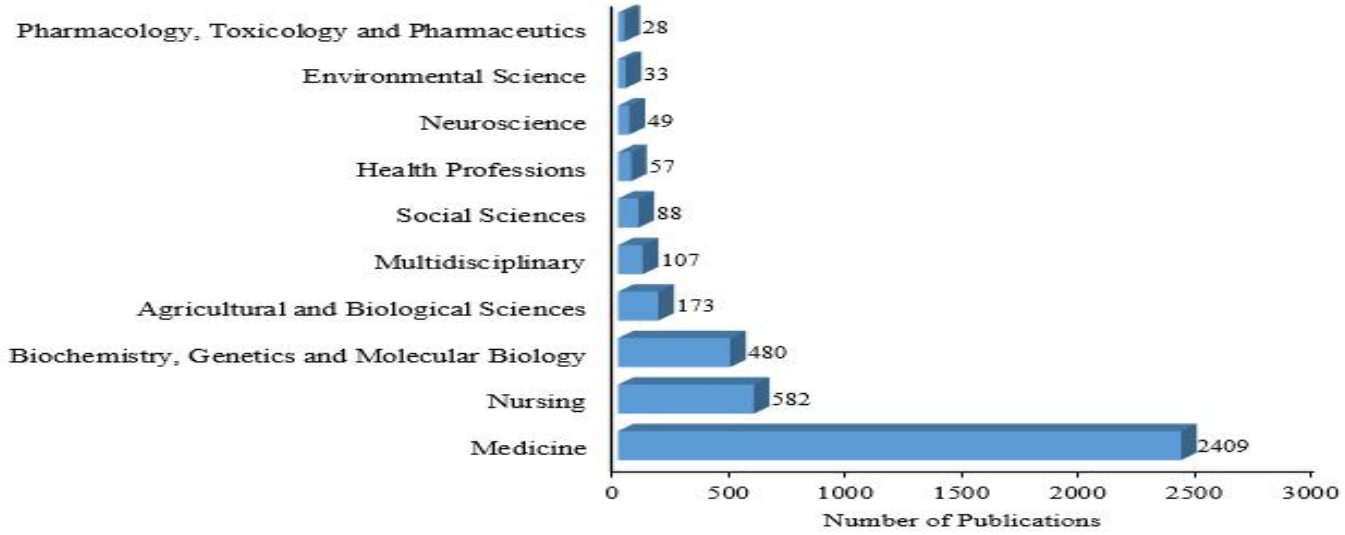


Figure 4. Top 10 subject categories based on the criteria for data classification

Table 2. Top 10 productive and Influential authors of Sarcopenia documents published (2002-2025)

Total Number of Publications	Total Number of Publications	Total Number of Publications	Total Number of Citations	Total Number of Citations	Total Number of Citations
Author	**H_index**	**TNP (PY_start)**	**Author**	**H_index**	**TNC (PY_start)**
Wang Y	15	74 (2020)	Onder G	10	3039 (2008)
Zhang Y	18	73 (2014)	Baracos VE	14	2640 (2010)
Liu Y	19	70 (2014)	Landi FL	13	2483 (2012)
Zhang X	24	68 (2014)	Zhang X	24	2323 (2014)
Chen X	19	62 (2016)	Prado CM	11	2266 (2012)
Li Y	12	58 (2018)	Bernabei R	8	2220 (2012)
Lee J	25	57 (2013)	Montano-Loza AJ	8	1966 (2012)
Wang X	13	54 (2016)	Liperoti R	5	1928 (2012)
CHEN Y	14	53(2016)	KIM K	20	1738 (2010)
KIM J	21	4(2013)	SAWYER MB	4	1732 (2010)

3.3 Author's productivity vs. the impact of Sarcopenia documents

A total of 11,758 authors contributed to sarcopenia-related publications **(Table 2)**. Among the top 10 most prolific authors, Wang Y had been publishing in this area for more than 5 years (first publication in 2020), and Zhang Y for more than 15 years (first publication in 2014); they are the most prolific researchers, with 74 and 73 publications, respectively. Onder G is distinguished by highly cited and influential contributions, with the largest accumulated number of citations (3,039; first citation to his publication in 2008) **(Table 2).** The collaborative network of the authors is depicted in **Fig. 5**, with a minimum of 10 publications per author and a minimum of 2,000 citations per author, resulting in only 59 authors meeting the thresholds. The collaboration analysis presented 5 distinct clusters with 627 links and a total link strength of 2,463. The relative scarcity of links between different teams suggests there was sufficient collaboration between research groups or labs conducting sarcopenia-related publications.

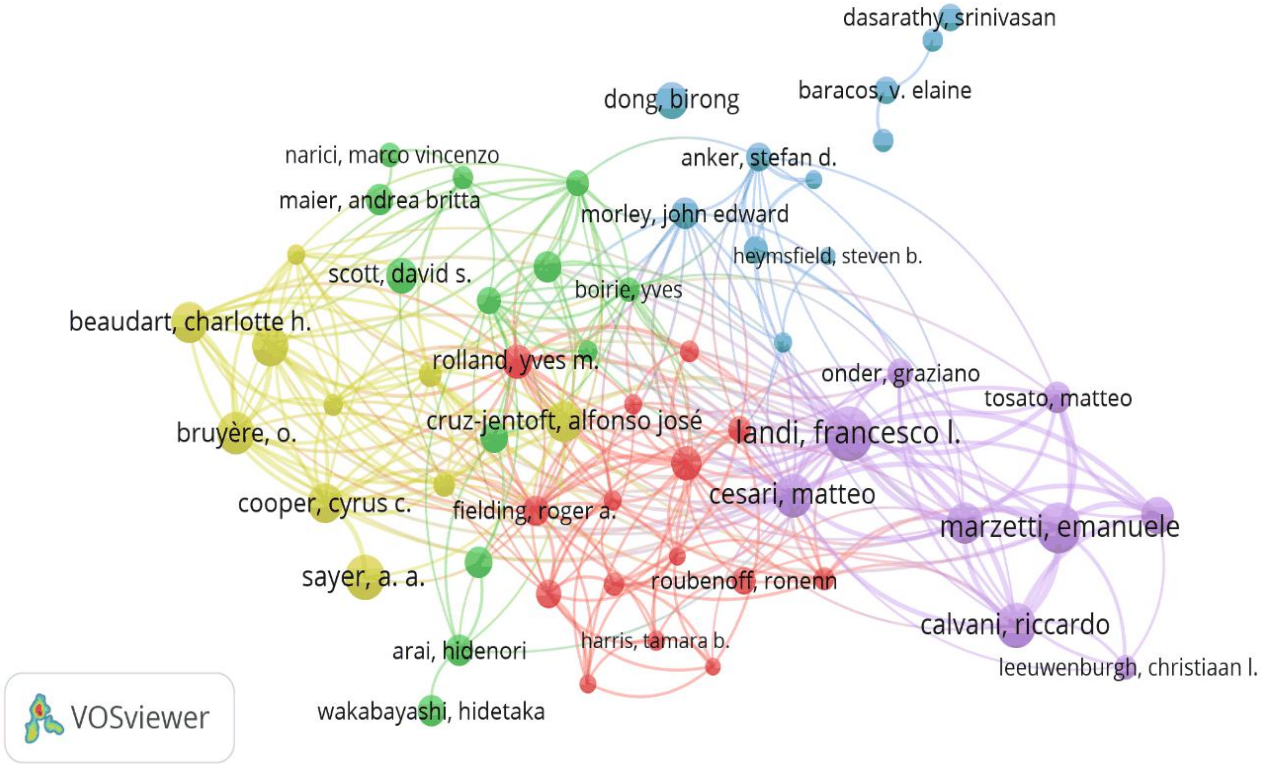


Figure 5: The collaborative network of the authors published on Sarcopenia-related publications.

Table 3. Top 10 documents on Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications, grouped by clinical research theme.

Theme	Title (reference)	Year	Cited by	What the study established
A. Definition and diagnostic criteria	Sarcopenia: its assessment, aetiology, pathogenesis, consequences and future perspectives [7]	2008	808	Early conceptual and diagnostic framework; sarcopenia as age-related muscle loss leading to frailty
	Sarcopenia: alternative definitions and associations with lower extremity function [20]	2003	781	Definition should account for body fat, particularly in women and overweight individuals
B. Functional complications	Sarcopenia and its association with falls and fractures in older adults: a systematic review and meta-analysis [37]	2019	782	Positive association with falls and fractures, consistent across definitions
	Sarcopenia as a risk factor for falls in elderly individuals: results from the iSIRENTE study [9]	2012	736	High prevalence using the EWGSOP algorithm; no gender difference
C. Prognostic value in organ-specific disease	Muscle wasting is associated with mortality in patients with cirrhosis [38]	2012	718	Sarcopenia associated with 40% mortality in cirrhosis; prognostic beyond standard liver disease scores
	Sarcopenia and mortality after liver transplantation [39]	2010	698	CT-measured muscle mass predicts post-transplant mortality more strongly than standard liver disease scores
	Sarcopenia and mortality risk in frail older persons aged 80 years and older: results from the iLSIRENTE study [19]	2013	518	Associated with 22% and doubled risk of all-cause mortality, independent of age and clinical variables
D. Mechanistic and therapeutic evidence	Reversal of cancer cachexia and muscle wasting by ActRIIB antagonism leads to prolonged survival [15]	2010	805	Preclinical proof of principle that cancer-induced muscle wasting is mechanistically reversible and can prolong survival in animal models
	Sarcopenic obesity or obese sarcopenia: a cross-talk between age-associated adipose tissue and skeletal muscle inflammation [40]	2017	693	Inflamed adipose tissue proposed as a primary driver accelerating age-related muscle loss
	Epidemiology of sarcopenia: prevalence, risk factors, and consequences [8]	2023	702	Modifiable risk factors identified; prevalence rising sharply in clinical populations (18–66%)

Table 3 highlights the most important research on sarcopenia, showing its strong connection to death, survival, and health risks. The evidence is clear: sarcopenia is a strong, separate warning sign for death and problems, especially in long-term illnesses like cirrhosis and cancer. New studies show that focusing on the

ActRIIB pathway in cancer-related muscle loss could help rebuild muscle and improve survival, leading to new treatment options. Reviews of many studies warn that sarcopenia may increase the risk of falls and fractures in older adults by up to 90%. Sarcopenia can vary a lot, from 10% to 66%, depending on how it is defined, with definitions that include fat mass being most helpful for clinicians. Most importantly, sarcopenia is a serious but changeable risk factor. Finding and treating it early can greatly improve patient health, help people stay independent, and help them live longer [7]–[9], [15], [19], [20], [37]–[40].

3.4 Major clinical research areas represented by the most-cited articles

Table 3 shows that the most-cited literature does not represent a single line of inquiry but four distinct clinical research areas, each reflecting a different question the field has asked about sarcopenia.

Area A — Definition and diagnostic criteria. The two articles in this area [7], [20] reflect the field's earliest priority: establishing what sarcopenia is and how it should be measured. The article by Newman et al. [20] is particularly important because it showed that definitions based on muscle mass alone misclassify individuals, and that body fat must be considered, especially in women and overweight individuals. This area established the conceptual foundation on which later prognostic work depends.

Area B — Functional complications. The two articles in this area [9], [37] reflect the field's move from description to functional consequence. They established that sarcopenia is associated with falls and fractures in older adults, and that the association holds across definitions. This area represents the geriatric and public-health perspective, in which the relevant outcome is not death but loss of mobility and independence.

Area C — Prognostic value in organ-specific disease. The three articles in this area [19], [38], [39] reflect the field's move into clinical prognosis. They established that sarcopenia predicts mortality in cirrhosis, in liver transplantation, and in frail adults aged 80 years and older, and that in transplantation, CT-measured muscle mass predicts mortality more strongly than conventional liver disease scores. This area represents the hepatology, transplantation, and geriatric medicine perspective, in which sarcopenia is used for risk stratification.

Area D — Mechanistic and therapeutic evidence. The three articles in this area [8], [15], [40] reflect the field's move toward mechanism and intervention. The ActRIIB study [15] provided preclinical proof of principle that cancer-induced muscle wasting is mechanistically reversible and can prolong survival in animal models. The sarcopenic obesity article [40] proposed inflamed adipose tissue as a driver of muscle loss. The epidemiology article [8] consolidated prevalence, risk factors, and consequences.

Read together, these four areas describe the field's trajectory: from defining sarcopenia (Area A), through documenting its functional consequences (Area B), to validating it as a prognostic marker in specific diseases (Area C), and finally to investigating mechanisms and treatments (Area D). This trajectory is not strictly chronological — Areas A and D overlap in time — but it reflects a shift in the field's centre of gravity from description toward clinical application.

Two cautions follow from this reading. First, the high citation counts of the ActRIIB study [15] reflect its influence on the research agenda, not established clinical benefit; no ActRIIB-targeted therapy is currently in routine clinical use. Second, the areas represented in Table 3 are determined by citation count, which favours older definitional and mechanistic papers that have had more time to accumulate citations. Newer prognostic and population-level studies may be under-represented in this table even though they define the current research frontier.

Table 4. Contributions of the top 10 most productive sources of Sarcopenia based on the number of Publications and Bradford Law, 2002-2025

Source	H_Index	TNC	TNP	PY_start	Bradford Law*
Journal of Cachexia, Sarcopenia and Muscle	56	11121	284	2011	Zone 1
Nutrients	22	1254	71	2017	Zone 1
BMC Geriatrics	21	1389	70	2015	Zone 1
FRONTIERS IN NUTRITION	14	532	67	2018	
Scientific Reports	19	1068	62	2017	Zone 1
Journal of Nutrition, Health and Aging	21	2226	57	2008	Zone 1
Clinical Nutrition	26	2448	47	2012	Zone 1
Geriatrics and Gerontology International	20	1730	43	2010	Zone 1
JOURNAL OF CLINICAL MEDICINE	15	723	43	2018	Zone 1
Plos One	16	828	37	2015	Zone 1
EXPERIMENTAL GERONTOLOGY	13	577	33	2016	Zone 1

Of the total number of sources, 765 were grouped into three groups based on Bradford's Law as follows: 14 (1.83%) peer-reviewed journals are located in Zone 1, 110 (14.38%) in Zone 2, and 641(83.79%) in Zone 3.

3.5 Top 10 sources of Sarcopenia

Of the total number of sources, 765 were grouped into three zones based on Bradford's Law: 14 (1.83%) peer-reviewed journals are in Zone 1, 110 (14.38%) in Zone 2, and 641 (83.79%) in Zone 3. Journal of Cachexia, Sarcopenia and Muscle leads with 284 articles (TNP = 284), followed by Nutrients with 71. The top ten journals in Zone 1 have published 744 articles. According to Bradford's Law, if this output is one-third of the total literature, the analysed corpus includes about 814 articles from Zone 1 **(Table 4).**

Table 5. Contributions of the top 10 most relevant corresponding authors' countries on Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications, 2002-2025

Country	Articles	Articles %	SCP	MCP	MCP %
China	879	32	813	66	7.5
Japan	348	12.7	330	18	5.2
Korea	262	9.5	240	22	8.4
Usa	172	6.3	140	32	18.6
Turkey	103	3.8	100	3	2.9
Brazil	95	3.5	67	28	29.5
Italy	83	3	56	27	32.5
United Kingdom	81	2.9	41	40	49.4
Australia	70	2.5	47	23	32.9
Germany	64	2.3	41	23	35.9

SCP: Single Country Publications; MCP: Multiple Country Publications; MCP %: Percentage of a country'stotal articles that are internationally collaborative.

3.6 Productive countries or regions, and institutions

Table 5 presents the top 10 countries by corresponding author. China leads with 32% of all articles (879), nearly three times more than Japan, the next highest contributor. East Asian countries (China, Japan, and South Korea) account for over 54% of the literature, indicating a strong regional focus. Chinese scholars have the most international collaborations (66 multi-country publications), followed by the United Kingdom

(40), the USA (32), and another country (28). The United Kingdom has the highest proportion of multi-country publications relative to its total output (49.4% MCP), followed by Germany (35.9% MCP), Australia (32.9% MCP), and Italy (32.5% MCP).

The Collaboration analysis between the top 50 countries is presented in Figure 6.

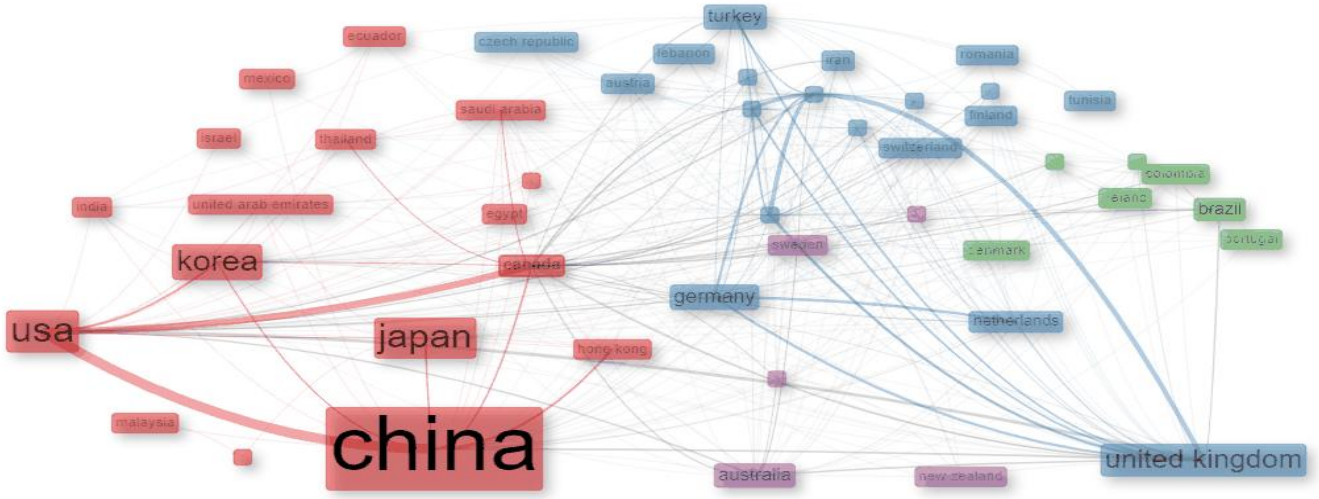


Figure 6. Collaboration analysis between the top 50 countries

Table 6. Contributions of the top 10 most productive institutions to research on Sarcopenia-related publications

Institutions	Count	Country
West China School of Medicine/West China Hospital of Sichuan University	89	China
Sichuan University	81	China
Capital Medical University	54	China
Yonsei University College of Medicine	39	South Korea
University of Melbourne	39	Australia
Chinese Academy of Medical Sciences & Peking Union Medical College	34	China
Wenzhou Medical University	33	China
University of Alberta	32	Canada
Seoul National University College of Medicine	31	South Korea
Ministry of Education of the People's Republic of China	31	China

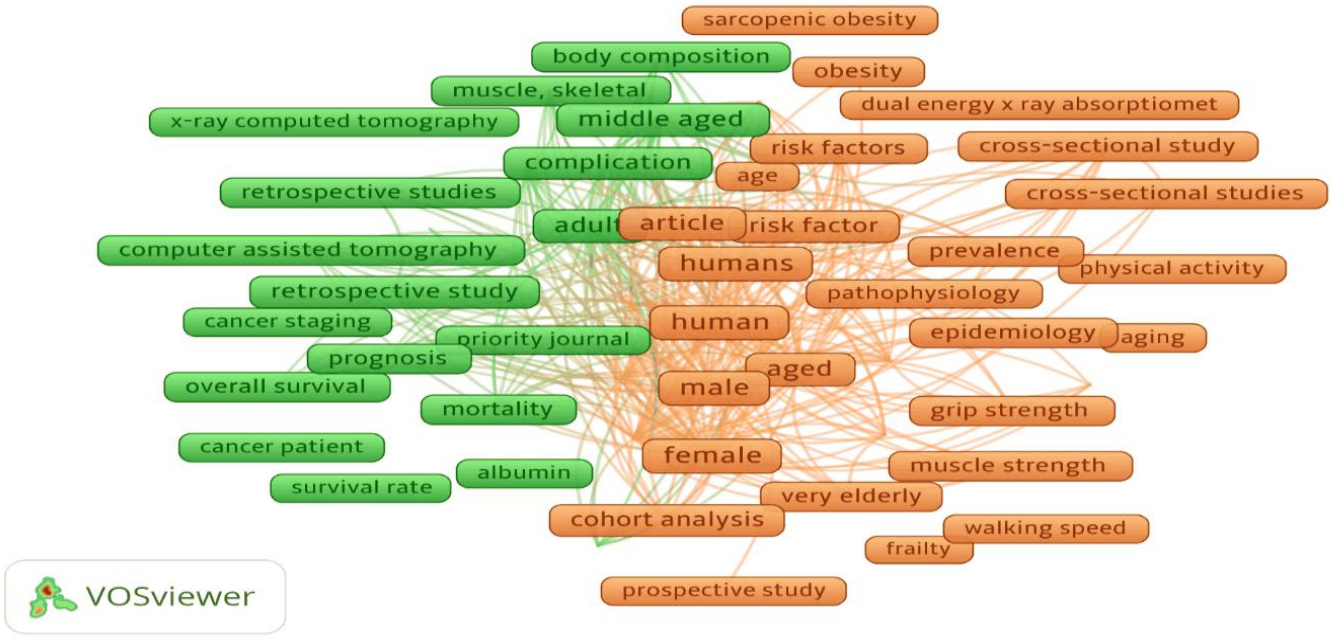
Table 6 shows that three of the top 10 institutions were from Europe, and the remaining were Chinese institutions. The West China School of Medicine/West China Hospital of Sichuan University ranked first (89) for the number of publications, followed by Sichuan University (81) and Capital Medical University (54), respectively.

Table 7. Contributions of the top 5 most funding sponsors on Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications, 2002-2025

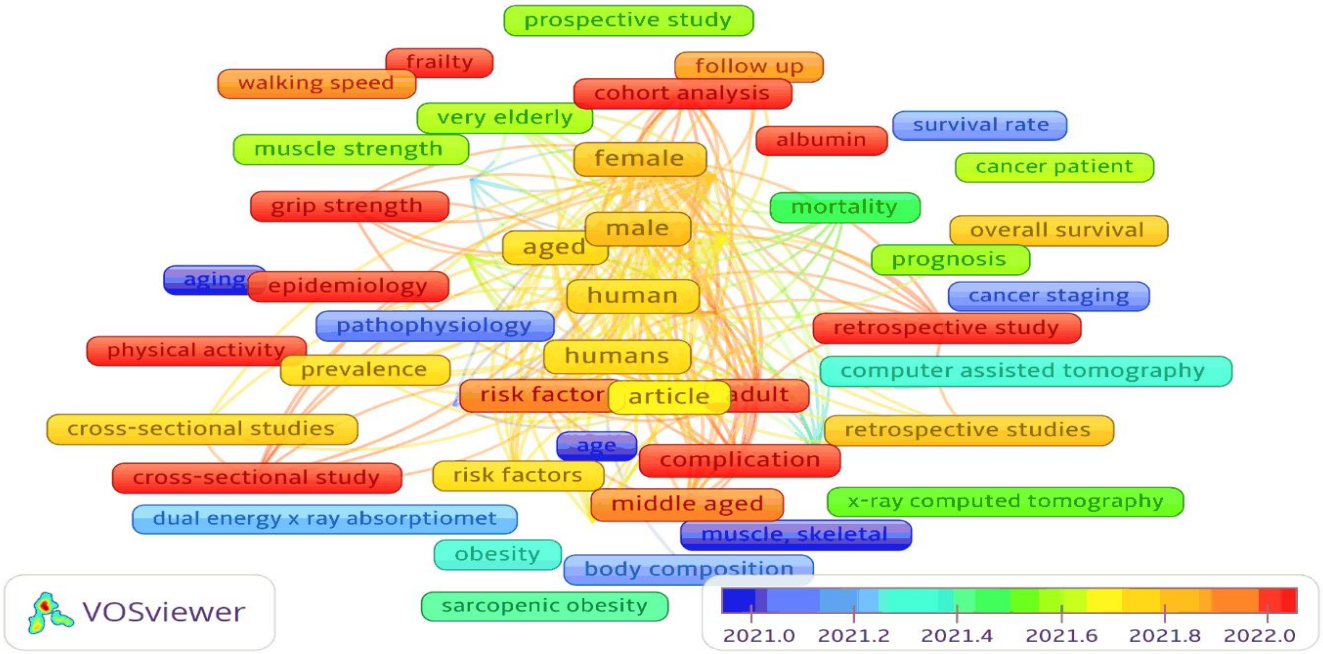
Funding sponsor (N=160)	TNP
National Natural Science Foundation of China	234
Japan Society for the Promotion of Science	133
National Research Foundation of Korea	78
National Institutes of Health	75
National Key Research and Development Program of China	74

The top 5 most funding sponsors

7. A



7.B



Of 160 reported funding organisations, support Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications. Most of the publications were funded by National Natural Science Foundation of China (TNP=234) documents, followed by the Japan Society for the Promotion of Science (TNP=133) documents, among others **(Table 7).**

7.C

Keywords	Year	Strength	Begin	End	2010 - 2020
muscle atrophy	2010	17.91	2010	2013	
adverse effects	2014	9.45	2014	2016	
republic of korea	2010	9.22	2010	2017	
radiography	2010	8.36	2010	2015	
nutrition surveys	2012	7.84	2012	2017	
nutrition	2012	7.84	2012	2017	
south korea	2014	7.59	2014	2017	
outcome assessment	2013	7.29	2013	2016	
statistics and numerical data	2015	7	2017	2018	
gait	2013	6.91	2013	2017	
physical performance	2012	6.61	2012	2015	
time factor	2017	6.02	2017	2018	
dual-energy x-ray absorptiometry	2012	5.48	2012	2015	
frail elderly	2012	4.99	2012	2017	
sex factor	2018	4.88	2018	2020	
x ray computed tomography	2017	4.79	2017	2018	
dual energy x ray absorptiometry	2010	4.73	2010	2015	
national health	2012	4.73	2012	2014	
albumin blood level	2016	4.69	2016	2017	
absorptiometry	2010	4.63	2010	2015	
disability	2017	4.6	2017	2018	
nutrition examination survey	2012	4.57	2012	2014	
body weight	2010	4.53	2013	2015	
korea	2013	4.37	2013	2014	
time factors	2013	4.36	2017	2018	

Figure 7. Research hotspots on Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications (A). Keyword co-occurrence network (B). Time-overlapping co-occurrence analysis network of keywords; (C). A list of 25 keywords with the strongest citation bursts.

3.7. Top 5 Most Funding Sponsors

Of 160 reported funding organisations, most publications were funded by the National Natural Science Foundation of China (TNP = 234), followed by the Japan Society for the Promotion of Science (TNP = 133), among others **(Table 7).**

3.8 Keyword analysis with the Strongest Citation Bursts

An analysis of 7,936 keywords related to sarcopenia, mortality, survival, and clinical complications was conducted using the Scopus database. Seventy-one high-frequency keywords were identified, forming two clusters with 2,485 connections and a combined link strength of 441,259. Fig. 7A visualises this network, where larger nodes represent more frequent keywords and closer nodes indicate stronger relationships. The largest cluster, with 44 keywords, centres on population-level sarcopenia research, emphasising geriatric and public health perspectives. This cluster highlights sarcopenia in older adults and clarifies key terms such as sarcopenia and sarcopenic obesity, both closely linked to frailty.

Researchers use various epidemiological and observational study designs, including cohort, cross-sectional, longitudinal, and prospective studies, to assess prevalence, risk, and disease associations. They employ standardised tools such as BMI, DXA scans for muscle mass assessment, and functional tests like grip strength and walking speed to measure and define sarcopenia. A central aim is to pinpoint modifiable risk factors, like inactivity, poor nutrition, obesity, and hypertension, alongside common comorbidities such as diabetes, to shape effective prevention strategies. This research cluster also delves into the biological underpinnings of muscle ageing. Collectively, these efforts position sarcopenia as a pressing geriatric syndrome and a major public health issue. Another key focus is harnessing sarcopenia assessment in oncology to improve patient outcomes. In this context, muscle mass becomes a powerful prognostic marker for survival, cancer staging, and treatment complications. Routine CT scans are used to evaluate body composition, while sophisticated statistical models connect muscle loss to critical outcomes like mortality and surgical success. This cluster highlights how sarcopenia assessment enables tailored risk prediction and personalised care in radiology and oncology **(Fig. 7B).**

The keyword network can be interpreted by distinguishing constructs related to the assessment of sarcopenia from constructs related to its clinical consequences. Assessment constructs include muscle mass, body composition, DXA, CT, grip strength, walking speed, and the sarcopenia index. Consequence constructs include mortality, overall survival, prognosis, cancer staging, complications, and disability. This distinction matters because the two groups of terms answer different questions: assessment terms describe how sarcopenia is identified, whereas consequence terms describe what sarcopenia predicts. In the co-occurrence network **(Fig. 7A),** the assessment and consequence constructs are not separate communities but are linked through a small number of bridging nodes, principally imaging and body-composition terms.

The imaging and body-composition nodes occupy an intermediate position in the network, connecting assessment nodes such as muscle mass and DXA to prognosis nodes such as overall survival, cancer staging, and mortality. In the time-overlay visualisation **(Fig. 7B),** these links are relatively weak in earlier periods and strengthen after approximately 2021, when terms related to CT-based body composition, cancer staging, and overall survival increasingly co-occur. This pattern is consistent with a shift in which sarcopenia assessment is increasingly used as a tool for clinical risk stratification, particularly in oncology, rather than solely as a descriptor of an age-related condition. However, co-word proximity reflects textual co-occurrence rather than demonstrated clinical utility, and this interpretation should therefore be regarded as hypothesis-generating rather than as evidence that assessment improves outcome prediction. Whether body-composition assessment adds incremental predictive value beyond existing clinical indicators is an empirical question that bibliometric data cannot answer, and it is identified below as a priority for future clinical research.

3.8.1 -Why a staged reading is needed

The burst analysis can be read as a sequence of successive research agendas rather than as a list of frequent terms **(Fig. 7C).** Burst detection identifies keywords that increased sharply in frequency within a defined period, and the timing of each burst therefore indicates when a topic became a focus of active investigation rather than merely a common term. Reading the bursts in chronological order reveals four overlapping stages. Read in this way, the bursts do not simply show which topics were frequent; they show where

scientific attention moved — from defining and measuring sarcopenia, to linking it to measurable outcomes, to testing whether it predicts adverse events, and finally to applying it in clinical settings.

3.8.2 - Stage 1: Descriptive and assessment era (2010–2017)

The earliest and strongest bursts belong to a descriptive and assessment-oriented era. "Muscle atrophy" showed the highest burst strength in the dataset (17.91, 2010–2013), accompanied by "radiography" (8.36, 2010–2015), "nutrition surveys" and "nutrition" (both 7.84, 2012–2017), "physical performance" (6.61, 2012–2015), and "frail elderly" (4.99, 2012–2017). The repeated appearance of "Republic of Korea" (9.22, 2010–2017) and "South Korea" (7.59, 2014–2017) indicates that much of this work drew on national health and nutrition survey cohorts. Taken together, this stage reflects efforts to define, measure, and describe sarcopenia in population-based samples.

3.8.3 - Stage 2: Early outcome orientation (2014–2018)

A second stage shows an early turn toward clinical outcomes. Bursts in "adverse effects" (9.45, 2014–2016), "outcome assessment" (7.29, 2013–2016), "statistics and numerical data" (7.00, 2017–2018), and "gait" (6.91, 2013–2017) indicate that investigators began to connect sarcopenia to measurable health consequences rather than only to its prevalence. The appearance of "time factor" (6.02, 2017–2018) and "time factors" (4.36, 2017–2018) is consistent with a growing interest in temporal outcomes, including survival and disease trajectories.

3.8.4 - Stage 3: Prognostic and risk-stratification framing (2017–2020) and Stage 4: Clinical application (after 2020)

A third stage reflects a prognostic and risk-stratification framing. Bursts in "disability" (4.60, 2017–2018), "sex factor" (4.88, 2018–2020), and "x-ray computed tomography" (4.79, 2017–2018) indicate increasing attention to who is at risk, what functional consequences follow, and how imaging can be used to quantify risk. After 2020, the burst pattern weakens, and the thematic evolution analysis (Fig. 8) shows that the most recent period is dominated by body composition, oncology, and population-level datasets, signalling movement toward clinical application. This four-stage sequence is consistent with a transition from describing sarcopenia as an age-related condition toward examining its role in predicting adverse outcomes. Burst timing alone, however, cannot establish that transition causally, and the thematic evolution analysis reported below provides convergent evidence for the same pattern. The value of this reading is that it converts a list of frequent terms into a description of how the field's attention shifted over time, and it identifies the most recent shift — toward clinical application — as the direction in which current research is moving.

Table 8. Thematic Evolution Analysis by Cluster: Index vs. Authors Keywords

Cluster	Callon Centrality **(CC)**	Rank Density **(CD)**	Rank Centrality **(RC)**	Rank Density **(RD)**	Cluster Frequency **(CF)**
Index Keywords	Index Keywords				
Cross-sectional study	1.717	4.744	2	3	17,350
Retrospective Study	1.487	3.899	1	2	9,700
human	4.108	2.615	3	1	37,350
Authors Keywords	Authors Keywords				
survival	0.264	5.489	2	3	1695
Sarcopenia	0.318	5.358	3	2	4862
Dynapenia	0.049	5.153	1	1	91

Thematic Evolution analysis

The "human" cluster was the most central and frequently used keyword, with the highest Callon Centrality and Cluster Frequency. "Cross-sectional study" was the most internally cohesive group, while "retrospective study" ranked highest in centrality. Among 250 authors, three main keyword clusters emerged. The "sarcopenia" cluster was the primary research focus. The "survival" cluster showed the strongest internal connections and the clearest theme. Although highly ranked, the "dynapenia" cluster remained rare and specialised **(Table 8).**

3.9.1. A Three-Layer Framework for Interpreting Thematic Evolution

The thematic clusters shown in Table 8 and Fig. 8 combine three conceptually different kinds of research activity, and interpreting them as a single sequence of topics obscures what has actually changed. We therefore distinguish three layers.

The biological-mechanism layer addresses the question of why muscle is lost. It includes themes such as insulin resistance, pathogenesis, inflammation, and the gut–muscle axis. The diagnostic-assessment layer addresses the question of how sarcopenia is identified. It includes themes such as DXA, CT, body composition, grip strength, and the sarcopenia index. The clinical-outcome layer addresses what sarcopenia predicts. It includes themes such as mortality, survival, prognosis, complications, and disability.

These layers are not interchangeable indicators of research activity. A rise in mechanistic terms indicates progress in understanding biology; a rise in assessment terms indicates progress in measurement; and a rise in outcome terms indicates that the field is testing whether sarcopenia matters clinically. **Table 8b** summarises the three layers, the question each addresses, and the period in which each was most prominent.

Table 8b: Three-layer interpretation of thematic evolution in sarcopenia research, 2002–2025

Layer	Representative themes	Question addressed	Period of greatest prominence	Interpretation
Biological mechanisms	Insulin resistance; pathogenesis; inflammation; gut–muscle axis	Why is muscle lost?	2002–2021	Established the biological basis of muscle loss and positioned sarcopenia as a systemic metabolic condition
Diagnostic assessment	DXA; CT; body composition; grip strength; walking speed; sarcopenia index	How is sarcopenia identified?	2012–2020, intensifying with imaging	Standardized measurement and enabled the reuse of routine clinical imaging for body-composition analysis
Clinical outcomes	Mortality; survival; prognosis; complications; disability	What does sarcopenia predict?	Expanding sharply from ~2017; dominant 2022–2025	Shifted the field from describing sarcopenia toward testing its prognostic and clinical value

Read through this framework, the thematic evolution shown in Fig. 8 is not a simple succession of topics but a shift in the relative weight of the three layers. The mechanism layer dominated the earliest period and established why muscle is lost. The assessment layer intensified between approximately 2012 and 2020 as imaging-based body composition became widely available, and it provided the measurement tools needed to test prognostic hypotheses. The outcome layer expanded sharply from approximately 2017 and dominates the most recent period, in which outcome themes are combined with causal-inference methods such as Mendelian randomisation and with large cohort datasets. This layered reading avoids treating mechanistic, diagnostic, and prognostic themes as equivalent indicators of research activity, and it clarifies that the field's recent growth reflects a move toward outcome evaluation rather than a renewed focus on mechanisms.

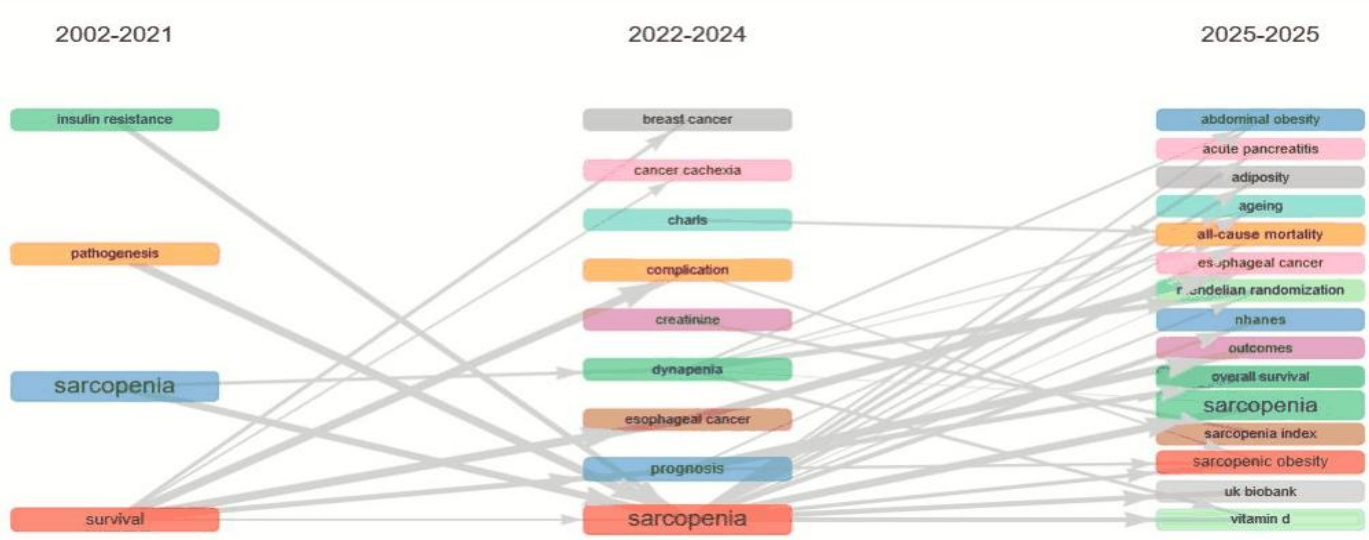


Figure 8. Thematic evolution of Sarcopenia in relation to Mortality, Survival, and Associated Clinical Complications within three Time Slices (2002-2021; 2022-2024; 2025-2025)

3.9.2. Thematic Evolution of Sarcopenia Trends in the Documents

Since 2002, research on sarcopenia and mortality has advanced considerably. Between 2002 and 2021, investigators introduced concepts including insulin resistance, pathogenesis, and survival. They clarified the biological mechanisms of muscle loss, its effect on survival, and established sarcopenia as a key concern in geriatric medicine.

From 2022 to 2024, research focused more on clinical oncology, especially breast cancer, cancer cachexia, and dynapenia. Sarcopenia became recognised as a significant prognostic factor in cancers such as breast and oesophageal cancer. Diagnostic methods improved with CT imaging and biomarkers like creatinine, and the role of muscle strength, or dynapenia, received greater attention. In 2025, research expanded to include abdominal obesity, acute pancreatitis, Mendelian randomisation, and the sarcopenia index. This phase uses advanced methods and examines a broader range of outcomes and populations. Researchers analyse large datasets, such as the UK Biobank and National Health and Nutrition Examination Survey (NHANES) and apply Mendelian randomisation to identify causal links. The field now addresses complex conditions like sarcopenia and obesity, explores new biomarkers such as the sarcopenia index, and increasingly incorporates epidemiological and public health perspectives **(Fig. 8).**

Considered through the three-layer framework in Table 8b, the chronological sequence described above reflects a change in emphasis rather than a replacement of earlier themes: mechanistic research continues, but the centre of gravity has shifted toward assessment and, most recently, toward clinical outcomes.

3.10. Outcome Domains and Clinical Populations

Coding of the 2,746 records by outcome domain showed an uneven distribution of research attention. Mortality was the largest domain, accounting for approximately 46% of outcome-coded records, and was concentrated in community-dwelling and frail older populations. Survival and prognosis accounted for approximately 34% of records and were concentrated in oncology, hepatology and transplantation, and cirrhosis. Clinical complications accounted for approximately 20% of records; within this domain, falls and fractures and postoperative morbidity were relatively well represented, whereas treatment intolerance and loss of functional independence were markedly under-represented. Coding by clinical population showed that community-dwelling/geriatric (approximately 38%) and oncology (approximately 27%) populations dominated the literature, followed by hepatology and transplantation (approximately 14%), perioperative populations (approximately 9%), nephrology and chronic kidney disease (approximately 7%), and other chronic disease (approximately 5%). These distributions are summarised in Table 9 and should be interpreted as descriptive, given the label-based coding approach.

Table 9. Research attention across clinical populations, outcome domains, assessment approaches, and future research directions

Clinical population	Dominant outcome domain	Relative research attention	Main assessment approach	Under-studied aspect	Future research direction
Community-dwelling / geriatric	Mortality; falls and fractures; disability	High for mortality and falls; low for functional independence	DXA; grip strength; walking speed; SARC-F	Loss of functional independence; patient-reported outcomes	Trials testing whether screening and intervention preserve independence
Oncology	Survival/prognosis; treatment tolerance	High for survival; low for treatment tolerance	CT body composition; skeletal muscle index	Dose-limiting toxicity; treatment modification	Prospective studies linking muscle status to treatment tolerance and dose modification
Hepatology / transplantation	Mortality; waitlist and post-transplant survival	High	CT skeletal muscle index	Integration into allocation algorithms	Prospective validation of muscle measures in transplant allocation scores
Nephrology / CKD	Mortality; dialysis outcomes	Moderate	CT; bioelectrical impedance	Practical tools for dialysis units	Validation of feasible tools in dialysis populations
Perioperative / surgical	Postoperative complications;	Moderate for morbidity;	CT; grip strength	Postoperative recovery and	Prehabilitation trials with

Clinical population	Dominant outcome domain	Relative research attention	Main assessment approach	Under-studied aspect	Future research direction
	mortality	low for recovery trajectory		functional trajectory	complication and recovery endpoints
Other chronic disease (diabetes, cardiovascular, respiratory)	Mortality; functional decline	Emerging / low	DXA; grip strength; biomarkers	Causal mechanisms; sarcopenia index validation	Mechanistic and causal studies; biomarker validation

Table 9b aligns the three bibliometric analyses on a common timeline. The upper panel shows the most-cited articles by theme **(from Table 3).** The middle panel shows the dominant keyword bursts by period **(from Figure 7C).** The lower panel shows the dominant thematic layer by period (from Table 8b and Figure 8). Three overlapping stages are indicated: Stage 1, definition and measurement (approximately 2000–2010); Stage 2, prognostic validation in clinical populations (approximately 2011–2019); Stage 3, population-level and causal inference (approximately 2020–2025). Stage boundaries are approximate and overlap, reflecting the coexistence of research agendas.

Table 9b. Integrated three-stage developmental model of sarcopenia outcome research

Stage	Period	Most-cited article themes (Table 3)	Dominant keyword bursts (Figure 7C)	Dominant thematic layer (Table 8b)	Methodological standard
Stage 1: Definition and measurement	~2000–2010	Definition and diagnostic criteria [7,20]	Muscle atrophy; radiography; nutrition surveys; physical performance	Biological mechanisms; early assessment	Consensus definitions; prevalence surveys
Stage 2: Prognostic validation	~2011–2019	Functional complications [37,9]; organ-specific prognosis [19,38,39]; mechanism/therapy [15,40]	Adverse effects; outcome assessment; gait; disability; sex factor; CT	Assessment intensifying; outcome layer expanding	Single-cohort and organ-specific prognostic studies
Stage 3: Population-level and causal inference	~2020–2025	Epidemiology and population consequences [8]	Body composition in oncology; population datasets	Clinical outcomes dominant	Large cohorts (UK Biobank, NHANES); Mendelian randomization

4. Discussion

In recent years, research on sarcopenia, mortality, survival, and related clinical complications has grown quickly and is reaching its peak in 2025. Earlier, unclear diagnostic criteria and definitions slowed progress. Since sarcopenia was officially recognised as a disease in the International Classification of Diseases (ICD) in 2016, the number of publications each year has risen sharply [41]. Many well-cited studies show that sarcopenia is a strong and independent predictor of mortality in different groups of people [7]–[9], [15], [19], [20], [37]–[40].

The epidemiology review reports a high and variable prevalence of sarcopenia (18%–66%), with the highest rates in clinical populations. It identifies several modifiable lifestyle risk factors: physical inactivity, poor nutrition, tobacco use, insufficient sleep, and diabetes. These factors offer clear targets for prevention strategies [39]. Evidence indicates that sarcopenia is an independent risk factor for death [15]. This association is consistent across diverse groups, including the general elderly population, where it doubles mortality risk in the iLSIRENTE studies; patients with chronic diseases such as cirrhosis, where prevalence reaches 40% and median survival is halved; and individuals undergoing major interventions like liver transplantation, where muscle mass predicts mortality more strongly than traditional liver disease scores. This broad impact highlights sarcopenia's fundamental role in health resilience [38].

Sarcopenia is also associated with negative clinical outcomes beyond mortality. Systematic reviews confirm that it significantly increases the risk of falls and fractures in older adults [37]. This demonstrates a direct link between muscle loss, disability, loss of independence, and reduced QOL. The literature also shows that the definition of sarcopenia affects who is identified. Obesity is a key factor, leading to "sarcopenic obesity" or "obese sarcopenia," in which inflamed adipose tissue is considered a primary driver of muscle wasting [40]. Mechanistic research has identified specific molecular pathways that regulate muscle wasting. A widely cited 2010 study showed that cancer-induced muscle wasting is mediated in part by the ActRIIB pathway, and that pharmacological blockade of this pathway restored muscle mass and prolonged survival in animal models of cancer cachexia, even without affecting tumour growth [15]. This is preclinical proof of principle: it establishes that muscle wasting is mechanistically reversible and that reversing it can influence survival in experimental models. It does not establish clinical efficacy. No ActRIIB-targeted therapy is currently approved or in routine clinical use for sarcopenia or cachexia, and the clinical translation of this pathway remains under investigation. The high citation count of this study reflects its influence on the research agenda — it opened a therapeutic direction — rather than evidence of clinical benefit in patients. More broadly, bibliometric influence is not equivalent to clinical evidence grade, and citation counts should not be read as evidence that an intervention works.

Bibliometrix R package evaluates author contributions by analysing publication frequency and citation counts. The results present the top 10 authors, each with over 1,732 citations. The most cited are Onder G (3,039 citations), Baracos VE (2,640), and Landi FL (2,483) [26]. China leads in research productivity, aligning with Xiao et al. (2022), who reported rapid growth in sarcopenia research in China compared to other countries [25]. The prominence of China, Japan, and South Korea in the literature on sarcopenia and adverse outcomes merits cautious interpretation. Three non-exclusive explanations are plausible. First, these countries are experiencing rapid population ageing, and geriatric syndromes including sarcopenia have received increasing policy attention, which creates both clinical demand and research funding for studies of older populations. Second, large, linkable national cohorts and health-examination databases are available — for example, the Korea National Health and Nutrition Examination Survey (KNHANES) [12] — and these databases allow sarcopenia prevalence and outcomes to be examined in representative samples. The burst analysis independently reflects this, with repeated bursts for "nutrition surveys," "Republic of Korea," and "South Korea" between 2010 and 2017. Third, research funding and institutional output have grown rapidly in Chinese universities and hospitals, consistent with the finding that the National Natural Science Foundation of China is the leading funding sponsor in this literature (Table 7). These are plausible interpretations rather than conclusions that can be drawn from publication counts: bibliometric data show where research is produced, not why. The geographic concentration is also a limitation, because it may bias the thematic landscape toward East Asian cohort designs and assessment practices, and it underscores the need to validate definitions and thresholds in other ethnic and regional populations.

4.1. From Geriatric Syndrome to Prognostic Marker

The keyword and thematic analyses indicate that the role of sarcopenia assessment in the literature has changed. Sarcopenia was initially investigated as a geriatric syndrome defined by low muscle mass in older adults, and its assessment served mainly to describe prevalence and to identify individuals at risk of functional decline [2], [6]. Over the past decade, however, sarcopenia assessment has increasingly been used as a prognostic tool, particularly in oncology, transplantation, and chronic disease. This shift is visible in the keyword network, where imaging and body-composition nodes have become linked to survival and prognosis nodes after approximately 2021, and in the thematic evolution, where the outcome layer has expanded sharply from about 2017.

The principal bridge between assessment and prognosis is CT-based body composition. CT scans are routinely obtained for cancer staging, surgical planning, and surveillance, and they can be reused to quantify skeletal muscle cross-sectional area, muscle density, and visceral adiposity at no additional radiation exposure or cost [48]. This reuse is what makes sarcopenia assessment attractive in oncology and transplantation: muscle measures can be extracted from imaging that is already part of standard care, and they can be linked to treatment tolerance, surgical complications, and survival. In transplantation, CT-derived muscle mass has been shown to predict post-transplant mortality more strongly than conventional liver disease scores [39], and in cirrhosis it is associated with mortality independent of standard prognostic indices [38].

The same properties that make CT attractive also limit it. CT is not universally available, particularly in primary care and in low-resource settings; it is not suitable for repeated monitoring because of cumulative radiation exposure; and it requires technical standardisation, including slice selection, segmentation methods, and cut-off values, which vary between studies [48]. These limitations mean that CT-based assessment is most applicable in specialist oncology and transplant settings, and less applicable to population screening or primary care.

For these reasons, cost-effective point-of-care alternatives are being developed. Ultrasound can quantify muscle thickness and quality at the bedside [49]; bioelectrical impedance analysis is portable and inexpensive [49]; and blood-based biomarkers, including the sarcopenia index derived from creatinine and cystatin C, are being evaluated as practical proxies for muscle mass [50]. Validating these tools across populations and establishing whether they carry the same prognostic information as CT, is a prerequisite for extending sarcopenia assessment beyond specialist centres. Until such validation is available, the current literature supports the use of CT-based body composition for risk stratification in oncology and transplantation, but not the routine use of sarcopenia assessment as a screening tool in unselected populations.

4.2. Association, Causation, and the Interpretation of Prognostic Signal

The literature consistently shows that sarcopenia is associated with mortality, complications, and functional decline, and the analyses reported above confirm that this association is a central theme of the field. This association should not be interpreted as proof that sarcopenia independently causes these outcomes. Low muscle mass and strength may act in at least three different ways. They may be a marker of underlying disease severity, chronic inflammation, malnutrition, or frailty, in which case their prognostic value reflects the severity of the condition that produced them rather than a direct causal effect. They may be a mediator, lying on the causal pathway between a disease process and an adverse outcome, in which case intervening on muscle loss could partially reduce risk. Or they may be a contributor, independently increasing vulnerability to falls, infection, treatment intolerance, and death. These roles are not mutually exclusive, and a single study cannot usually distinguish between them [42].

Observational and bibliometric data cannot resolve this question. Association in cohort studies may reflect confounding by disease severity, age, comorbidity, or inflammation; bibliometric data describe the distribution of research attention rather than the underlying biology. For this reason, we use the terms "associated with," "predicts," and "prognostic marker" throughout the manuscript, and we reserve causal

language for studies that use designs capable of supporting causal inference, such as Mendelian randomisation [42]. Even those designs carry assumptions — including the absence of pleiotropy and the validity of the genetic instrument — and their findings require triangulation with experimental and clinical evidence.

The distinction matters clinically. If sarcopenia is principally a marker, its main value lies in risk stratification, and intervention may not change outcomes. If it is a mediator or contributor, intervention may improve them. Distinguishing marker from cause is therefore a prerequisite for deciding whether screening and treatment programmes are justified, and it is the reason we identify causal-inference studies as a research priority below. The bibliometric data presented here cannot answer this question; they identify where the question is being asked and where the evidence remains incomplete.

4.3. Outcome Meaning Differs by Clinical Population

Sarcopenia does not carry the same prognostic meaning in every clinical setting, and presenting it as a single entity with a single prognostic value obscures clinically important heterogeneity. The literature supports four distinct population patterns.

In oncology, low muscle mass and low muscle density are most closely linked to treatment tolerance, dose-limiting toxicity, surgical morbidity, and survival [51]. Their clinical value lies principally in treatment planning: patients with low muscle mass may require dose modification, closer monitoring, or prehabilitation before surgery. In this population, sarcopenia is primarily a treatment-tolerance and prognosis marker.

In hepatology and liver transplantation, muscle mass predicts waitlist and post-transplant mortality beyond conventional liver disease scores, and CT-derived muscle measures are increasingly considered in transplant assessment [39]. Here sarcopenia functions as an allocation and risk-stratification marker, and its clinical relevance is tied to decisions about who receives a transplant and when.

In nephrology and chronic kidney disease, sarcopenia is associated with mortality and adverse dialysis outcomes, but assessment is complicated by fluid status, inflammation, and the limitations of body-composition tools in dialysis populations [52]. Here, sarcopenia functions as a risk marker in a population with high comorbidity burden, and practical assessment tools remain a priority.

In community-dwelling and frail older adults, the dominant consequences are falls, fractures, functional decline, and loss of independence, with mortality risk approximately doubled in frail cohorts [19], [37]. Here sarcopenia functions as a functional and geriatric marker, and the outcomes that matter most to patients — mobility, independence, and quality of life — are precisely those that are least often measured as primary endpoints.

These differences have three implications. First, a single definition and a single cut-off cannot carry the same meaning across specialities, because the outcome being predicted differs. Second, the assessment tool that is appropriate differs by setting: CT-based body composition is feasible in oncology and transplantation but not in primary care, where grip strength, gait speed, and bioelectrical impedance are more practical [49]. Third, the research gaps differ by population: treatment-tolerance studies are needed in oncology, functional-independence trials in geriatric populations, and practical tool validation in nephrology. Table 9 summarises these population-specific patterns, the dominant outcome domain in each, the assessment approach used, and the corresponding research gap.

4.4. Historical Phases and the Three-Layer Framework

Studies showed that research before 2021 mainly addressed the definition and pathophysiology of sarcopenia [25]. Insulin resistance, pathogenesis, sarcopenia, and survival are often examined collectively in the literature, reflecting ongoing efforts to elucidate their biological interconnections [42]. Sarcopenia is increasingly recognised as an active metabolic disorder with the potential to cause mortality and is now regarded as a distinct clinical condition [43]. Research on sarcopenia and mortality has evolved from investigations of basic mechanisms to clinical and, more recently, population-level studies. The integration

of nutrition, exercise, hormones, and select anabolic drugs has been proposed as a strategy to slow sarcopenia in ageing populations [44]. Since 2002, the field has progressed through several phases. Between 2002 and 2021, studies primarily focused on defining sarcopenia and exploring its biological underpinnings.

Recent findings have established a strong association between gut microbiota and muscle health, with numerous studies linking muscle loss to adverse outcomes and increased mortality [45]. From 2022 to 2024, research emphasised clinical applications, particularly in oncology, utilising imaging modalities such as CT scans and biochemical markers like creatinine for diagnosis. In 2025, the focus shifted toward population-based and causal studies, leveraging large datasets such as the UK Biobank and NHANES, as well as advanced analytical techniques [46], [47].

4.5. Synthesis: Three Developmental Stages of Sarcopenia Outcome Research

The three-layer framework in Table 8b distinguishes what kind of research activity each theme represents — biological mechanism, diagnostic assessment, or clinical outcome. The present synthesis addresses a different question: in what order did these layers gain prominence? Read together, the layered framework and the chronological synthesis show that the field progressed from asking why muscle is lost, to asking how sarcopenia is measured, to asking what sarcopenia predicts.

The citation analysis (Table 3), the keyword and burst analysis (Fig. 7), and the thematic evolution analysis (Fig. 8) have been presented separately, but they describe a single developing field. Read together, they identify three overlapping stages.

Stage 1 — Definition and measurement (approximately 2000–2010). The most-cited articles from this period are definitional and methodological [7], [20]. The keyword bursts centre on "muscle atrophy," "radiography," "nutrition surveys," and "physical performance," and the thematic clusters are dominated by pathogenesis and insulin resistance. The task of this stage was to establish what sarcopenia is and how it should be measured.

Stage 2 — Prognostic validation in clinical populations (approximately 2011–2019). The most-cited articles from this period are organ-specific prognostic studies in cirrhosis, liver transplantation, and frail older adults [19], [38], [39], together with the ActRIIB proof-of-principle study [15] and the falls and fractures meta-analysis [37]. The keyword bursts shift toward "adverse effects," "outcome assessment," "gait," "disability," "sex factor," and "x-ray computed tomography." The task of this stage was to test whether sarcopenia predicts outcomes in specific patient groups.

Stage 3 — Population-level and causal inference (approximately 2020–2025). The most recent literature is characterised by large cohort datasets such as the UK Biobank and NHANES, by Mendelian randomisation, and by new biomarkers such as the sarcopenia index [46], [47]. The thematic clusters are dominated by body composition in oncology, abdominal obesity, acute pancreatitis, and all-cause mortality. The task of this stage is to move from association toward causal inference and population-level risk prediction.

This three-stage reading provides the organising logic for the remainder of the Discussion. It also clarifies why the field's growth after 2020 does not represent a new topic but a new methodological standard: the same questions about mortality, survival, and complications are now being addressed with causal-inference designs rather than with descriptive or single-cohort studies. The progression across the three layers is therefore not a simple replacement of one research agenda by another. Mechanistic research continues, and new mechanistic questions — including the gut–muscle axis and the role of inflammation — remain active. What has changed is the relative weight of the layers: the field's centre of gravity has moved from mechanism, through measurement, to outcome prediction. This is why the most recent literature is dominated by outcome terms and by methodological innovations such as Mendelian randomisation and large cohort datasets, while mechanistic terms persist as background. The layered framework and the chronological synthesis together make this progression visible; neither alone would show it.

4.6. Which Outcomes Are Studied, and Which Are Neglected

The distribution of research attention across outcome domains is uneven, and the imbalance has clinical consequences. Mortality is the most extensively studied domain. This is unsurprising, because death is a definitive, readily ascertainable endpoint and because large cohort and registry datasets permit mortality linkage [47]. Survival and prognosis form the second largest domain, concentrated in oncology, hepatology and transplantation, and cirrhosis, where muscle measures are used for risk stratification and treatment allocation [39]. Clinical complications form the smallest domain, and within it the distribution is itself uneven: falls and fractures and postoperative morbidity are relatively well studied, whereas treatment intolerance and loss of functional independence are markedly under-represented [37], [51].

This imbalance matters for three reasons. First, treatment intolerance is the outcome through which sarcopenia most directly influences cancer care, because low muscle mass is associated with dose-limiting toxicity and treatment modification [51]. If this outcome remains under-studied, the practical value of sarcopenia assessment in oncology will remain uncertain. Second, loss of functional independence is the outcome most relevant to older adults and to health and social care systems, yet it is rarely the primary endpoint of sarcopenia research [19]. Third, the relative neglect of complications means that the literature provides a stronger evidence base for prognosis than for prevention of the outcomes that patients themselves experience.

These findings should be interpreted cautiously. The coding was label-based, and a study that reports mortality may also have collected complication data without referring to it in the title or abstract. The distribution therefore indicates the *stated* focus of the literature rather than the full content of every study. Nevertheless, the pattern is consistent with the keyword and burst analyses, which show a strong and sustained emphasis on mortality, prognosis, and survival, and comparatively weaker representation of treatment tolerance and functional outcomes. On this basis, we identify three priorities: prospective studies with treatment-tolerance endpoints in oncology; trials with functional-independence endpoints in geriatric populations; and routine reporting of complications alongside mortality in cohort studies.

The bibliometric findings identify research priorities, but they do not demonstrate that screening for sarcopenia or treating it improves survival, reduces complications, or preserves independence. Several forms of evidence are still required before sarcopenia assessment and management can be recommended as routine clinical practice.

First, incremental predictive value. Studies must establish whether sarcopenia assessment improves risk prediction *beyond* existing clinical indicators, rather than merely being associated with outcomes. This requires reporting incremental discrimination (change in C-statistic), net reclassification improvement, and decision-curve analysis, in which the clinical usefulness of a new marker is evaluated against existing models. An association with mortality is not sufficient; the question is whether adding a muscle measure change clinical decisions. Second, randomised outcome trials. Adequately powered randomized controlled trials must determine whether intervention-driven improvement in muscle mass or strength translates into measurable improvements in hard outcomes — mortality, complications, functional independence, and quality of life — rather than only in intermediate measures such as muscle mass or gait speed. Trials should be stratified by clinical population, because the outcomes that matter differ between oncology, transplantation, nephrology, and community-dwelling older adults. Third, feasible and cost-effective assessment tools. The most practical and cost-effective assessment approach for primary care, geriatrics, and non-oncology specialities must be identified and standardised. CT-based body composition is feasible in oncology and transplantation but not in primary care; ultrasound, bioelectrical impedance analysis, and blood-based biomarkers such as the sarcopenia index require validation against CT and against outcomes before they can replace it in these settings. Fourth, population-specific cut-offs. Thresholds must be validated in the populations in which they will be used. A cut-off derived from oncology cohorts may not carry the same prognostic meaning in community-dwelling older adults, and cut-offs derived from East Asian cohorts may not apply to other ethnic groups. Reporting of cut-offs should specify the population, the assessment tool, and the outcome for which the threshold was derived. Fifth, causal-inference studies. Causal relationships among muscle loss, adiposity, inflammation, and mortality should be examined using

designs capable of supporting causal inference, including Mendelian randomisation and mediation analysis. As noted above, these designs carry their own assumptions and require triangulation with experimental and clinical evidence. They are necessary, however, to determine whether sarcopenia is a modifiable contributor to adverse outcomes or principally a marker of underlying disease. These five requirements are the clinical counterpart to the bibliometric findings. The present analysis does not answer them; it identifies where the literature has concentrated and where it has not, and it is intended to prioritise the clinical studies that are still needed.

4.9. Future Research Implications

Future bibliometric and systematic reviews should prioritise reproducibility and comprehensiveness. Researchers should use multi-database searches (Scopus, WoS, PubMed, Embase) with transparent, reproducible strategies and develop standardised, validated search filters for sarcopenia research to improve comparability. Interdisciplinary and international collaboration is essential. The field is moving from descriptive prognosis to understanding causal mechanisms, from standardised assessment to accessible interventions, and from regional studies to global, collaborative science focused on improving patient outcomes. Definitions that account for body fat are more clinically relevant. CT scans in oncology are not feasible in all settings. Emerging research on biomarkers such as the "sarcopenia index" (2025) should be validated. Cost-effective, point-of-care diagnostic tools such as ultrasound, bioelectrical impedance analysis, and blood-based biomarkers should be standardised for use in primary care, geriatrics, and other specialties. Recent trends show a shift toward genetic and causal inference methods, including Mendelian approaches. Studies should prioritise these methods to clarify the relationships among muscle loss, adiposity (sarcopenic obesity), inflammation, and mortality. Integrating omics technologies such as genomics and proteomics will help identify molecular drivers. Large-scale, randomised controlled trials on multimodal interventions in nutrition, exercise, and pharmacotherapy tailored to specific patient subgroups are needed. Strategies to reverse sarcopenia should be developed and tested to determine if improvement directly reduces mortality and complications.

4.10. Limitations

This study has several limitations. First, the analysis used a single database (Scopus). Although Scopus has broad coverage, articles indexed only in Web of Science, PubMed, or Embase were not captured, and citation counts differ between databases. Second, the search was restricted to English-language articles and reviews, which may under-represent research published in other languages, particularly from East Asia. Third, the clinical-population and outcome-domain coding was based on titles, abstracts, and keywords rather than full-text review, and is therefore approximate; records addressing multiple domains were assigned to a dominant category, which may misclassify some studies. Fourth, keyword co-occurrence and burst detection reflect textual patterns and cannot demonstrate clinical utility or causal relationships. Fifth, citation counts are affected by publication age and by field-specific citation practices, so that older definitional papers accumulate citations that newer prognostic papers have not yet had time to accrue. Sixth, the geographic concentration of output in East Asia may shape the thematic landscape and limit generalisability. Finally, this is a bibliometric analysis and does not estimate pooled effect sizes for mortality, survival, or complications; outcome-specific systematic reviews and meta-analyses remain necessary.

5. Conclusion

This bibliometric analysis shows that research linking sarcopenia to adverse clinical outcomes has passed through three overlapping stages. The first stage (approximately 2000–2010) established definitions and measurement. The second stage (approximately 2011–2019) validated sarcopenia as a prognostic marker in specific clinical populations, particularly cirrhosis, liver transplantation, oncology, and frail older adults. The third stage (approximately 2020–2025) is characterised by population-level datasets, causal-inference methods, and the integration of body composition into routine clinical imaging.

List of acronyms

United States of America (USA) -Quality of life (QOL)-Tumour necrosis factor-α (TNF-α)- C-reactive protein (CRP) -Gross Domestic Product (GDP) - Single Country Publications (SCP)- Multiple Country Publications (MCP)-Percentage of a country's rank centrality (MCP %) - Callon Density (CD)- Callon Centrality (CC)- Ran Density (y(RD)- Cluster Frequency (CF)-International Classification of Diseases (ICD)

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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.

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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.

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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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