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Unveiling the Knowledge Frontier: A Scientometric Analysis of COPD with Sarcopenia

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Objective: Numerous articles and reviews addressing the intersection of Chronic Obstructive Pulmonary Disease (COPD) with sarcopenia have been documented. However, a significant gap exists in the literature concerning scientometric analysis in this field. This study aimed to concentrate on recent research and elucidate emerging research areas through the examination of COPD with sarcopenia.

Methods: Articles in the field were systematically retrieved from the Web of Science Core Collections (WoSCC) spanning from 2003 to 2022. The analysis employed scientometric and keyword analyses through specialized software, including VOSviewer, CiteSpace, and Origin.

Results: A comprehensive analysis of 758 articles and reviews in the field of COPD with sarcopenia revealed the United States as the leading contributor in terms of publications and overall influence. Maastricht University emerged as the most prolific institution, with Schols Annemie M. W. J. being identified as the most influential scholar in this field. The International Journal of Chronic Obstructive Pulmonary Disease emerged as the most prolific journal. Notably, COPD with sarcopenia exhibits frequent associations with other diseases, underscoring the complexity of the topic and emphasizing the necessity for comprehensive treatment. Mechanistic and diagnostic aspects, particularly computed tomography, are pivotal in this research field. Osteoporosis emerges as a prospective avenue for future research, encompassing both COPD and sarcopenia. Furthermore, nutrition and physical activity are integral components for managing COPD patients with sarcopenia.

Conclusion: This study delineates the distribution of fields, the knowledge structure, and the evolution of major research topics related to COPD with sarcopenia. The identification of keyword hotspots enhances the understanding of the occurrence, development, and future study trends associated with the topic.

Keywords: chronic obstructive pulmonary disease, COPD, sarcopenia, scientometric analysis, visualization

Introduction

Chronic Obstructive Pulmonary Disease (COPD), a globally pervasive respiratory disease remains the cause of attributable deaths at a rate of 41.9 per 100,000. Over the past three decades, the overall prevalence has increased by 5.9% with a small difference between genders.[1] Factors like smoking, second-hand smoke exposure, genetic, predisposition, and developmental, and social influences contribute to the progression of COPD to an irreversible stage. Diagnosis relies on identified risk factors, symptoms such as cough and sputum, and spirometry results indicating persistent airflow obstruction.[2] Guidelines for COPD management underscore preventive measures (eg, vaccinations, smoking cessation, and avoidance of exposures) and the treatment manageable traits, including dyspnea, exacerbations, and comorbidities, like sarcopenia, osteoporosis, and others.[3,4]

Sarcopenia, a frequently discussed concurrent condition with COPD, manifests as a gradual and widespread decline in skeletal muscle in the elderly population, encompassing reduced muscle strength and mass, as well as muscle quality.[5]

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Introduced into consensus definitions in 2010 and recognized as an independent disease in 2016, sarcopenia lacks a singular diagnostic criterion despite widely acknowledged definitions by the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) and the Asian Working Group for Sarcopenia 2019 (AWGS2019).[6,7] A recent meta-analysis revealed varying sarcopenia the prevalence (10–27%) due to diverse classifications and cut-off thresholds in studies.[8] Typically diagnosed using dual-energy X-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA), sarcopenia assessment is complemented by computed tomography (CT) for emphysema characterization in COPD. Emerging tools include CT-morphometric measurement for structure-function associations and CT-quantitative analysis of muscle mass and adipose tissue for assessing disease severity and prognosis in COPD with sarcopenia.[9,10]

The literature on COPD with sarcopenia encompasses comprehensive reviews, system reviews, and meta-analysis covering relevance,[11,12] mechanisms,[13] prevalence,[14,15] diagnosis and treatment,[16] and even pathogenesis based Chinese traditional medicine theory.[17,18] However, a notable gap exists in a comprehensive scientometric analysis of the existing literature.

In this article, statistical methods and visualization tools such as CiteSpace and VOSviewer are employed to examine current structures and future trends.[19,20] An illustrative example is the bibliometric and visual analysis of mesenchymal stem cells (MSCs) and pulmonary fibrosis (PF) research, effectively summarizing the present state of clinical trials in this field.[21] Scientometric analysis, previously applied to depressive disorder research, identifies primary areas of investigation and summarizes associated keywords through manual classification.[22] Leveraging these methods, we propose future research directions for COPD with sarcopenia by combining current literature and scientometric analysis.

Data and Methods

Research Process

The Web of Science (WoS) database is the preeminent resource in bibliometric studies, surpassing general databases in both usage frequency and the abundance of scientific publications, offering a more extensive array of data sources. A search was systematically conducted in the WoS Core Collection database employing specific terms: (TS= (Pulmonary Disease, Chronic Obstructive) OR AB=(Chronic Obstructive Pulmonary Diseases OR Chronic Obstructive Lung Disease OR COPD)) AND (TS=(Sarcopenia) OR AB=(Sarcopenia OR Sarcopenias OR Muscle atrophy OR Sarcopenic OR Muscle attenuation OR Muscle loss OR Muscle depletion)) on 5 October 2023 and time span limited to 2003–2022. Exclusively, articles and reviews published in English were considered, excluding diverse document types, such as early access, book chapters, meeting abstracts, and letters. Figure 1 elucidates the process of scientometric analysis and provides additional pertinent details.

Data Analysis

VOSviewer (version 1.6.19) offers three distinct analyses for scientific cooperation networks: network visualization, overlay visualization, and density visualization. The tool played a pivotal role in conducting bibliometric analysis, exploring collaborations among countries/regions and affiliations, author and co-cited author interactions, co-cited references, and keyword co-occurrences. Additionally, it generated maps for network visualization and overlay visualization. To illustrate the dual-map overlay depicting COPD-related journals with sarcopenia and references featuring citation bursts, CiteSpace (version 6.2.R6) was employed. The comprehensive management of data, analytical support, and creation of tables and figures were seamlessly executed using Origin Pro 2022. The table was improved with the inclusion of Impact Factors (IF) for journals and the H-index for countries/regions, enhancing the depth of the scientometric analysis.

Results

Annual Publication Quantity

Between 2003 and 2022, an exhaustive search identified a total of 758 studies (comprising 588 articles and 170 reviews) related to COPD with sarcopenia. Analyzing the search results in the WoS, the annual publication output reveals into two indicates periods. The first stage, spanning from 2003 to 2012, exhibits a gradual yet consistent growth, while the second

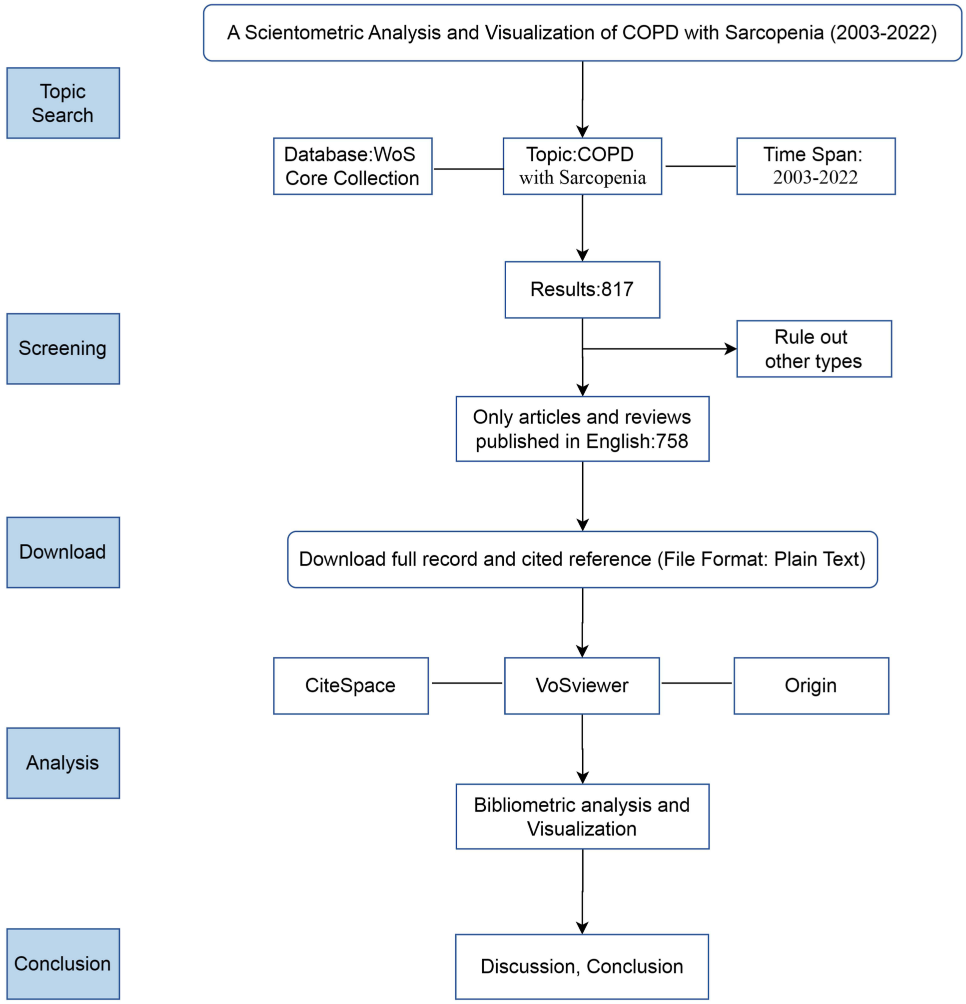


Figure 1 Flow chart illustrating the scientometric analysis process.

stage, from 2013 to 2022, indicates a more rapid expansion (Figure 2). Sarcopenia's introduction in 2010 precedes a period before 2013 with fewer than 30 studies per year on the subject. Post 2014, a notable surge in annual publications is evident. However, the impact of COVID-19 appears to have led to a modest decline in publications in 2019 and 2020, resulting in a brief plateau. Despite this, the overall trend indicates a heightened publication rate in recent years.

Countries/Regions and Affiliations

The VOSviewer network visualization map illustrates node size corresponding to the number of publications by a country/region or affiliation. For visual analysis, countries/regions with frequencies of at least 3 (n=35) and affiliations with frequencies of at least 7 (n=36) were selected. Subsequently, a cooperation network was established considering publication quantity and connections within each country/region and affiliation (Figure 3A and B). Line thickness connecting nodes indicates the level of cooperation or citation between projects. Authors are distributed across 57 countries/regions and 1,109 affiliations. As shown in Figure 3A and C, the USA leads with over 170 publications (n=173, 22.82%). Netherlands, England, Spain, and China follow, contributing to over 500 publications (66.36% of the total). Notably, close cooperation exists between the USA and Spain, USA and Netherlands, Netherlands and England. These developed countries contribute significantly, potentially due to COPD with sarcopenia being a global challenge, garnering more funding from developed countries. Examining Figure 3B and D, Maastricht University (Netherlands) tops with 45 publications (5.94%), followed by Pompeu Fabra University (Spain), Royal Brompton & Harefield NHS Foundation Trust (England), National Institute of Health Carlos III (Instituto de Salud Carlos III, Spain), and University

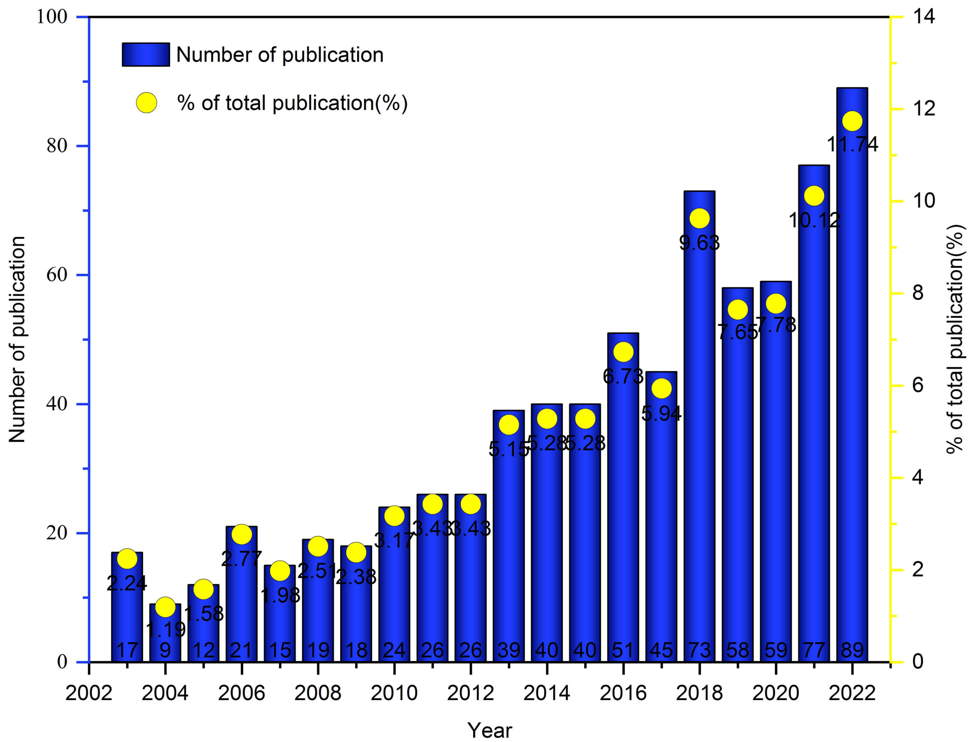


Figure 2 Annual publication quantity from 2003 to 2022 related to COPD with sarcopenia.

of Barcelona (Spain). Utilizing H-index and global rank as reliable measures of scientific achievements or influence, it is evident that the USA, Netherlands and Spain exhibit robust scientific prowess in COPD with sarcopenia research.

A substantial portion (44.86%) of total publications pertains to the respiratory system, geriatrics and gerontology (Figure 4). Chronic respiratory diseases, ranking as the third leading cause of death (7.0% of all deaths), r trail behind cardiovascular diseases and neoplasms. Notably, COPD, a major chronic respiratory ailment, significantly contributes to global mortality and disability driven by aging populations and chronic exposure to inhaled particulate matter.[1] The nuanced understanding of COPD with sarcopenia involves multidisciplinary approaches encompassing pharmacology, critical care, internal medicine, nutrition, exercise and rehabilitation, facilitating personalized management.[16,23] Thus, there is a higher prevalence of physiology-related publications (9.89%), followed by medicine general internal (9.37%) and nutrition dietetics (8.31%). Studies indicate that interventions such as multistrain probiotics or oral protein supplements can enhance muscle strength and physical abilities in COPD patients with sarcopenia.[24,25] Notably, sport science and rehabilitation contribute 5.94% to total publications, underscoring their therapeutic potential against COPD with sarcopenia.[26,27] Furthermore, various categories, including multidisciplinary science and neuroscience, highlight the intricate associations of COPD with sarcopenia with other diseases emphasizing the necessity for comprehensive treatment strategies.

Journals and Co-Cited Journals

The literature on COPD with sarcopenia encompasses 303 academic journals, with Table 1 highlighting the top 10 journals in this domain. International Journal of Chronic Obstructive Pulmonary Disease leads with 32, publications 4.22%, followed by Journal of Applied Physiology (25 publications, 3.30%) and Journal of Cachexia, Sarcopenia and Muscle (24 publications, 3.17%). Notably, among the top 10 journals, 5 are based in the United States, 4 in England, and 1 each in New Zealand and Switzerland. In this list, 7 journals belong to the Q1 section of the JCR quartile. Furthermore, 6 journals boast IF greater than 5, including Journal of Cachexia, Sarcopenia and Muscle (IF=8.9), European Respiratory Journal (IF=24.3), Respiratory Research (IF=5.8), Thorax (IF=10), Chest (IF=9.6), and American Journal of Respiratory and Critical Care Medicine (IF=24.7). Despite International Journal of Chronic Obstructive Pulmonary Disease having

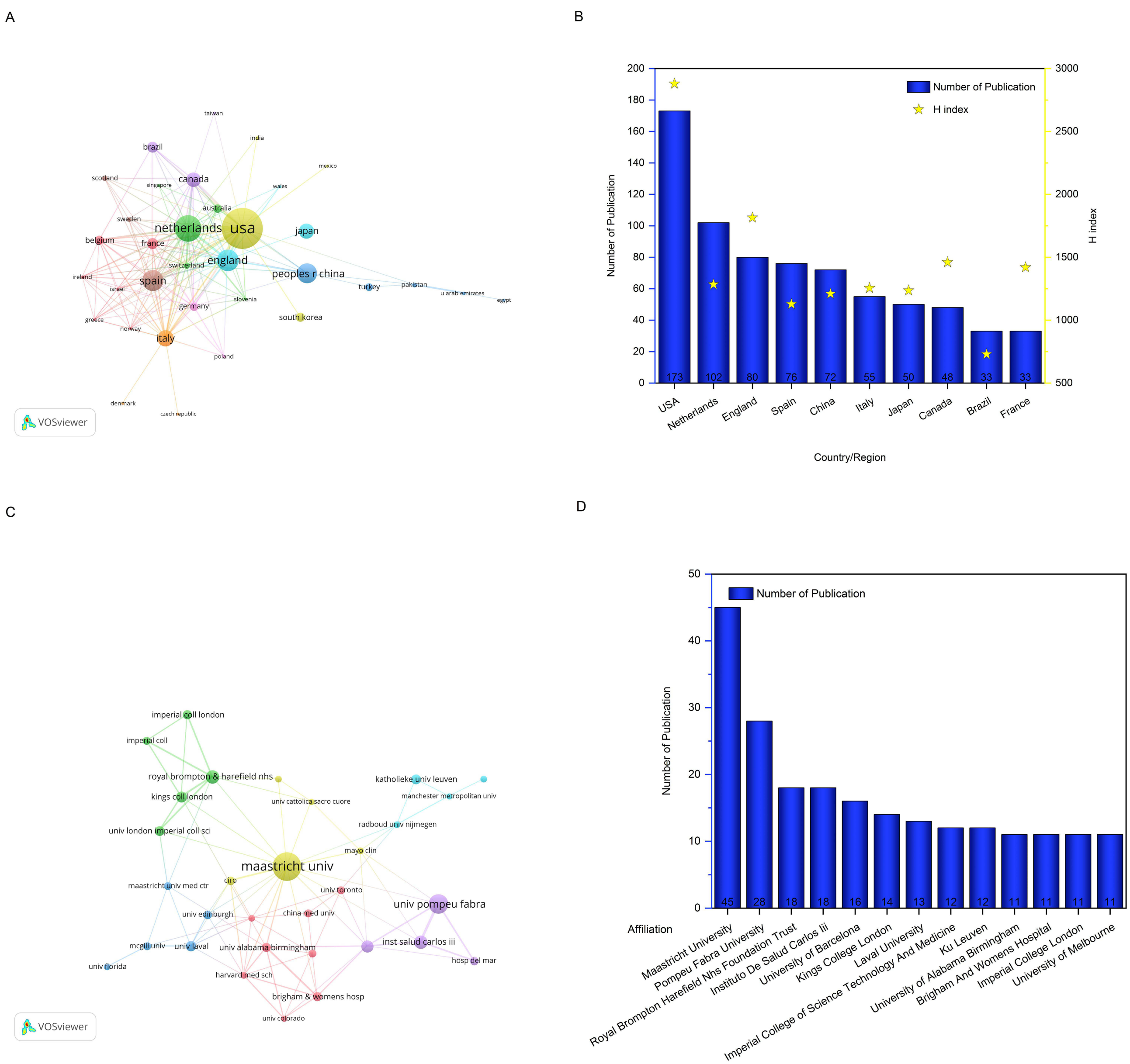


Figure 3 Cooperation map illustrating the countries/regions and affiliations.

Notes: (**A**) Network visualization of countries/regions. (**B**) Number of publications and H-Index scores for countries/regions. (**C**) Network visualization of affiliations. (**D**) Number of publications and global affiliations rank.

the lowest impact factor among the top 10 (IF=2.8), it has significantly contributed to the field. Interestingly, numerous publications related to COPD with sarcopenia are published in journals with lower impact factors, indicating a focus on sarcopenia as a comorbidity of respiratory diseases in general. This suggests a demand for further research in this interdisciplinary field.

Based on the number of citations (Table 2), American Journal of Respiratory and Critical Care Medicine leads with 3,244 citations, followed by European Respiratory Journal (2,144), Thorax (1,405), Journal of Applied Physiology (1,348), and Chest (1,172). Notably, 8 journals fall within the Q1 region of the JCR quartile, and 7 journals boast impact factors - exceeding 5. These include American Journal of Respiratory and Critical Care Medicine (IF=24.7), European Respiratory Journal (IF=24.3), Thorax (IF=10), Chest (IF=9.6), American Journal of Clinical Nutrition (IF=7.1), Journal of Cachexia, Sarcopenia and Muscle (IF=8.9), and NEJM (IF=158.5). In comparison with the earlier journal analysis, the

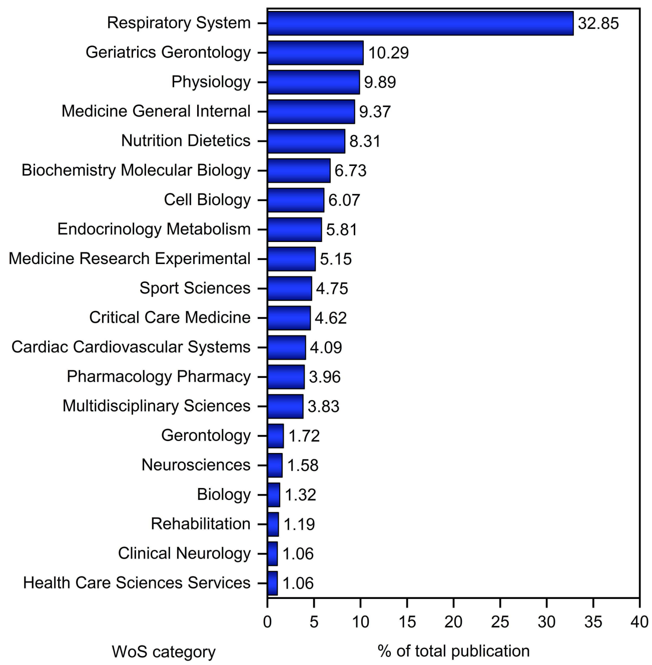


Figure 4 Category exploration map related to COPD with sarcopenia.

co-cited top journal exhibits a notable increase in JCR quartile, indicative of the study's scientific rigor and robust theoretical foundation.

Analyzing the relationship of citations between journals and co-cited journals performed using CiteSpace software through a dual-map overlay of journals.[19] The yellow and green lines represent primary application paths. The yellow lines indicate research published in journals focused on molecular, biology, and immunology, with main citations found in molecular, biology, and genetics journals. The green lines signify research published in journals focused on medicine, medical, and clinical, with main cited studies found in molecular, biology, genetics, health, nursing, and medicine journals (Figure 5).

Table 1 Top 10 Journals Related to COPD with Sarcopenia

Rank	Number of Publication	% Total of Publication	Journal	Country/ Region	JCR Quartile	Impact Factor(2022)	H-index (2022)
1	32	4.22%	International Journal of Chronic Obstructive Pulmonary Disease	New Zealand	Q3	2.8	NA
2	25	3.30%	Journal of Applied Physiology	USA	Q2	3.3	251
3	24	3.17%	Journal of Cachexia, Sarcopenia and Muscle	USA	Q1	8.9	88
4	22	2.90%	European Respiratory Journal	Switzerland	Q1	24.3	267
5	16	2.11%	Respiratory Medicine	England	Q1	4.3	134
6	16	2.11%	Scientific Reports	England	Q2	4.6	282
7	14	1.85%	Respiratory Research	England	Q1	5.8	120
8	14	1.85%	Thorax	England	Q1	10	242
9	13	1.72%	Chest	USA	Q1	9.6	315
10	12	1.58%	American Journal of Respiratory and Critical Care Medicine	USA	Q1	24.7	404
10	12	1.58%	Plos One	USA	Q2	3.7	404

Table 2 Top 10 Cited Journals Related to COPD with Sarcopenia

Rank	Citation	Cited Journal	Country/ Region	JCR Quartile	Impact Factor (2022)	H-index (2022)
1	3244	American Journal of Respiratory and Critical Care Medicine	USA	Q1	24.7	404
2	2144	European Respiratory Journal	Switzerland	Q1	24.3	267
3	1405	Thorax	England	Q1	10	242
4	1348	Journal of Applied Physiology	USA	Q2	3.3	251
5	1172	Chest	USA	Q1	9.6	315
6	746	American Journal of Clinical Nutrition	USA	Q1	7.1	368
7	678	Journal of Cachexia, Sarcopenia and Muscle	USA	Q1	8.9	88
8	662	Respiratory Medicine	England	Q1	4.3	134
9	597	Plos One	USA	Q2	3.7	404
10	509	New England Journal of Medicine	USA	Q1	158.5	1130

Authors and Co-Cited Authors

A total of 3,828 authors were identified through the publication search, forming a cooperation network with those who have published at least 5 (n=60) papers. Table 3 highlights the top three authors with a minimum of 20 publications. Schols Annemie MWJ exhibits the largest nodes based on publication count. And a close cooperation was observed between Schols Annemie MWJ and Gosker Haary R, Barreiro Esther and Gea Joaquim, Polkey Michael I, Kemp Paul R and Hopkinson Nicholas S, Wouters Emiel FM and Spruit Martijn A, Maltais Francois and Debigare Richard, and (Figure 6A).

Among the 20,180 co-cited authors, 18 received more than 100 citations in relevant publications. The highest number of co-citations (n=392) belongs to Schols Annemie MWJ, followed by Barreiro Esther (n=355) and Gosker Haary R (n=242). Figure 6B illustrates the co-citation network graph, analyzing authors with ≥80 co-citations. Positive cooperative relationships among various co-cited authors are indicated, featuring pairs such as Schols Annemie MWJ and Gosker Haary R, Schols Annemie MWJ and Engelen Marielle PKJ, Barreiro Esther and Maltais Francois, as well as Anker SD and Von Haehling S.

Publications and Co-Cited References

The analysis of publications in WoS (Table 4) revealed that 4 out of 758 publications received citations exceeding 500. Among the top 10 cited articles, the majority focused on pathogenesis and prognosis related to sarcopenia.

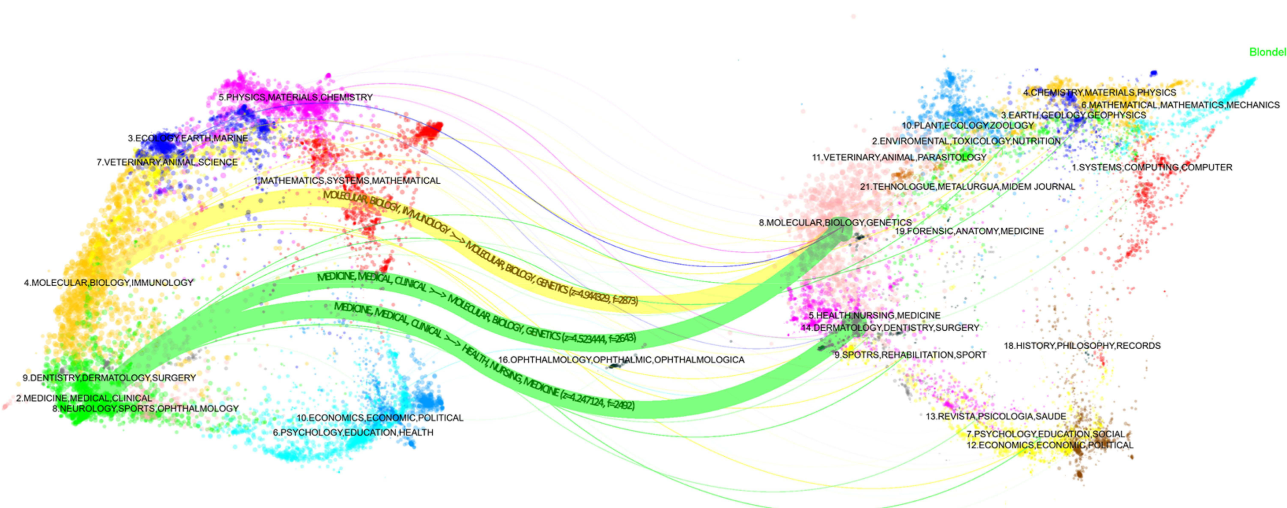


Figure 5 Dual-map overlay depicting journals related to COPD with sarcopenia.

Table 3 Top 10 Authors and Co-Cited Authors Related to COPD with Sarcopenia

Rank	Author	Count	Rank	Co-cited Author	Citation
1	Schols Annemie M. W. J.	34	1	Schols Annemie M. W. J.	392
2	Barreiro Esther	28	2	Barreiro Esther	355
3	Gea Joaquim	20	3	Gosker Haary R.	242
4	Gosker Haary R.	18	4	Cruz-Jentoft A.J.	209
5	Polkey Michael I.	17	5	Engelen Marielle P. K. J.	195
6	Wouters Emiel F.M.	15	6	Maltais Francois	179
7	Kemp Paul R.	14	7	Marquis Kathleen	131
8	Langen Ramon C.J.	12	8	Celli Bartolome R.	130
9	Maltais Francois	12	9	Spruit Martijn A.	122
10	Hopkinson Nicholas S.	9	10	Decramer Marc	121
10	Franssen Frits M.E.	9	10	Morley John E.	121
10	Muhammad Tahir	9	10	Barnes Peter J.	121
10	Qaisar Rizwan	9	NA	NA	NA

In the domain related to COPD with sarcopenia, a cumulative total of 28,551 co-cited references were identified, simultaneously cited by other publications. Table 5 lists the top 10 co-cited references concerning COPD with sarcopenia, each with a minimum of 63 co-citations.[28–37] Figure 7 presents the co-citation network diagram,[6,28–56] analyzing references with ≥42 (n=30) co-citations. Notably, "Marquis K, 2002, Am J Resp Cri Care"[28] exhibits active co-citation relationship with "Swallow EB, 2007, thorax".[31] Among the top 10 co-cited references, the predominant focus is on body composition (skeletal muscle mass), mortality and clinical correlates in COPD.

References with Citation Bursts

The red bar in Figure 8 signifies citation bursts, indicating an increased number of citations in a specific field at a particular time. Using CiteSpace software, we identified 10 references with significant citation bursts.[6,11,14,32,37,47,51,56–58] Furthermore, we delineated the minimum burst duration in relation to COPD with sarcopenia research. As depicted in the figure, the earliest and latest citation bursts occurred in 2012 and 2020, respectively. Among these references, "Sarcopenia: revised European consensus on definition and diagnosis" (authored by Cruz-Jentoft AJ et al) exhibited the strongest citation burst (strength = 17.82), observed between 2019 and 2022. In summary, the burst strength of the top 10 references varied between 9.33 and 17.82, with durations ranging from 1 to 4 years. We condensed the primary research content of the 10 references with the strongest citation bursts and presented it in Table 6.

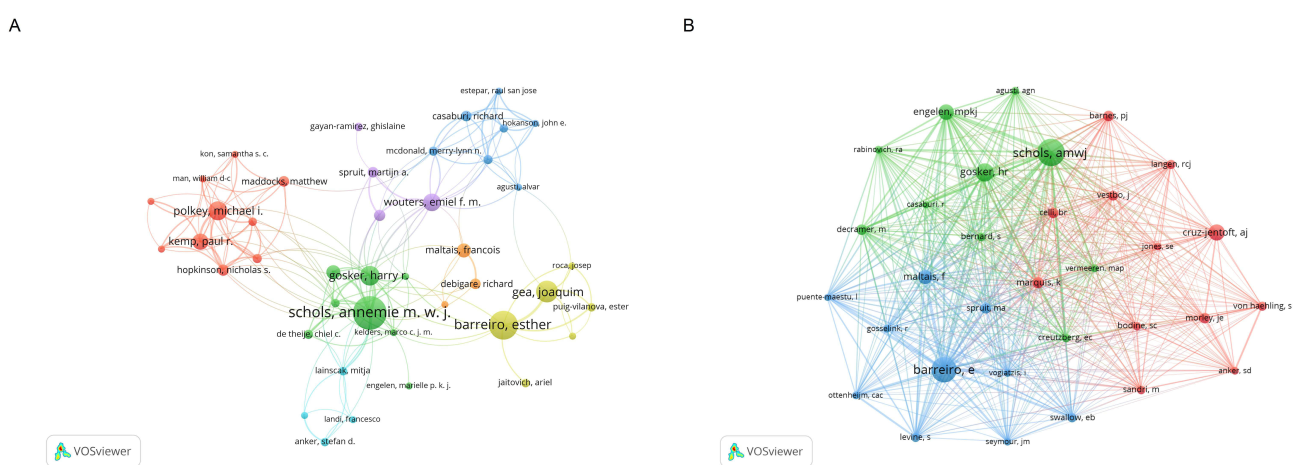


Figure 6 Network visualization map for authors and co-cited authors.
Notes: (**A**) authors and (**B**) co-cited authors related to COPD with sarcopenia.

Table 4 Top 10 Cited Articles Related to COPD with Sarcopenia

Rank	Citation	The Title of Article	Year	Cited Journal	Country/ Region	JCR Quartile	Impact Factor (2022)	H-index (2022)
1	1577	Oxidative stress, aging, and diseases	2018	Clinical Interventions in Aging	New Zealand	Q3	3.6	96
2	655	Muscle wasting in disease: molecular mechanisms and promising therapies	2015	Nature Reviews Drug Discovery	England	Q1	120.1	370
3	588	Systemic effects of chronic obstructive pulmonary disease	2003	European Respiratory Journal	Switzerland	Q1	24.3	267
4	548	Body composition and mortality in chronic obstructive pulmonary disease	2005	American Journal of Clinical Nutrition	USA	Q1	7.1	368
5	418	The Continuum of Aging and Age-Related Diseases: Common Mechanisms but Different Rates	2018	Frontiers in Medicine-Lausanne	Switzerland	Q2	3.9	71
6	413	Sarcopenia and mortality risk in frail older persons aged 80 years and older: results from ilSIRENTE study	2013	Age and Ageing	England	Q1	6.7	160
7	371	Signaling pathways controlling skeletal muscle mass	2014	Critical Reviews in Biochemistry and Molecular Biology	England	Q1	6.5	117
8	357	Intermuscular Fat: A Review of the Consequences and Causes	2014	International Journal of Endocrinology	USA	Q3	2.8	74
9	355	Associations of grip strength with cardiovascular, respiratory, and cancer outcomes and all-cause mortality: prospective cohort study of half a million UK Biobank participants	2018	BMJ-British Medical Journal	England	Q1	105.7	NA
10	305	Sarcopenia: A Time for Action. An SCWD Position Paper	2019	Journal Of Cachexia, Sarcopenia And Muscle	USA	Q1	8.9	88

https://doi.org/10.2147/COPD.S448494

Table 5 Top 10 Co-Cited References Related to COPD with Sarcopenia

Rank	Citation	The Title of Reference	Author	Year	Journal	DOI
1	130	Midthigh muscle cross-sectional area is a better predictor of mortality than body mass index in patients with chronic obstructive pulmonary disease.[28]	Marquis Karine	2002	American Journal of Respiratory And Critical Care Medicine	DOI 10.1164/RCCM.2107031
2	115	Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People.[29]	Cruz-Jentoft Alfonso J.	2010	Age and Ageing	DOI 10.1093/AGEING/AFQ034
3	108	Body composition and mortality in chronic obstructive pulmonary disease.[30]	Schols Annemie M. W. J.	2005	American Journal of Clinical Nutrition	DOI 10.1093/AJCN/82.1.53
4	97	Quadriceps strength predicts mortality in patients with moderate to severe chronic obstructive pulmonary disease.[31]	Swallow Elisabeth B.	2007	Thorax	DOI 10.1136/THX.2006.062026
5	85	Sarcopenia in COPD: prevalence, clinical correlates and response to pulmonary rehabilitation.[32]	Jones Sarah E.	2015	Thorax	DOI 10.1136/THORAXJNL-2014-206,440
6	80	Peripheral muscle weakness in patients with chronic obstructive pulmonary-disease.[33]	Bernard Sarah	1998	American Journal of Respiratory And Critical Care Medicine	DOI 10.1164/AJRCCM.158.2.9711023
7	74	The body-mass index, airflow obstruction, dyspnea, and exercise capacity index in chronic obstructive pulmonary disease.[34]	Celli Bartolorne R.	2004	New England Journal of Medicine	DOI 10.1056/NEJMOA021322
8	65	Weight loss is a reversible factor in the prognosis of chronic obstructive pulmonary disease.[35]	Schols Annemie M. W. J.	1998	American Journal of Respiratory and Critical Care Medicine	DOI 10.1164/AJRCCM.157.6.9705017
9	64	ATS statement: Guidelines for the six-minute walk test.[36]	Crapo Robert O.	2002	American Journal of Respiratory and Critical Care Medicine	DOI 10.1164/RCCM.166/1/111
10	63	An Official American Thoracic Society/European Respiratory Society Statement: Update on Limb Muscle Dysfunction in Chronic Obstructive Pulmonary Disease Executive Summary.[37]	Maltais Francois	2014	American Journal of Respiratory and Critical Care Medicine	DOI 10.1164/RCCRN.201402–0373ST

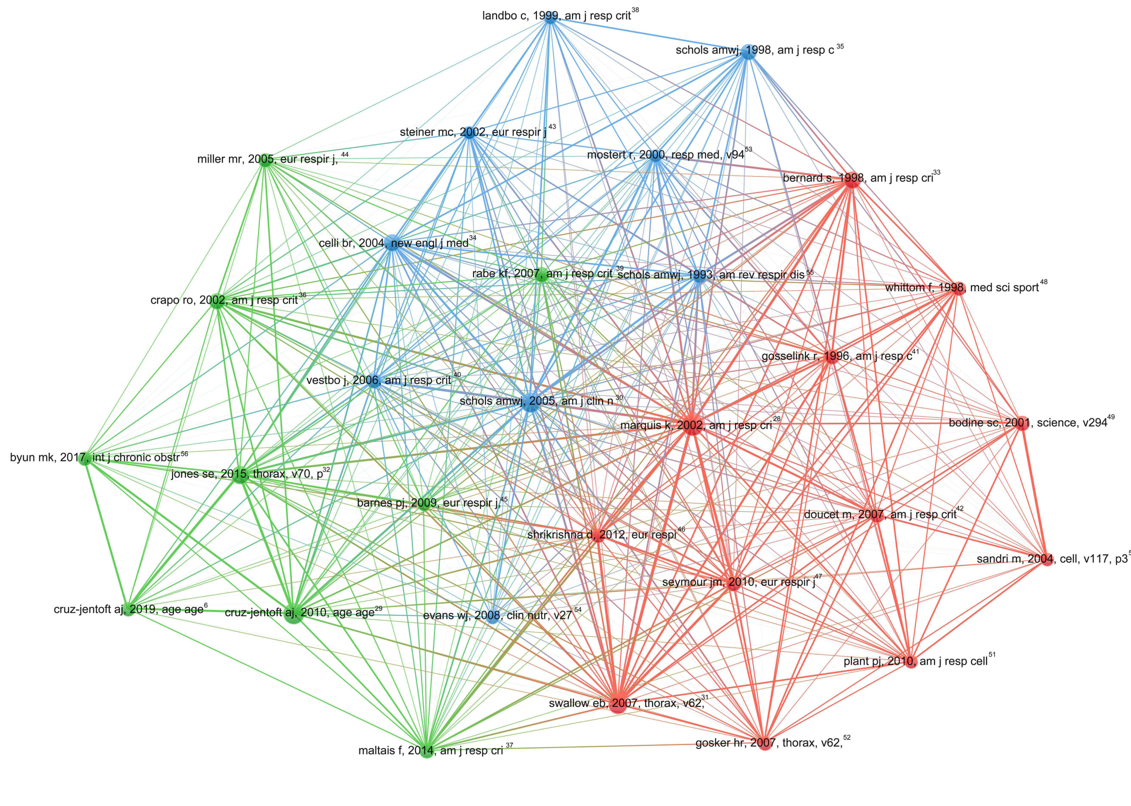
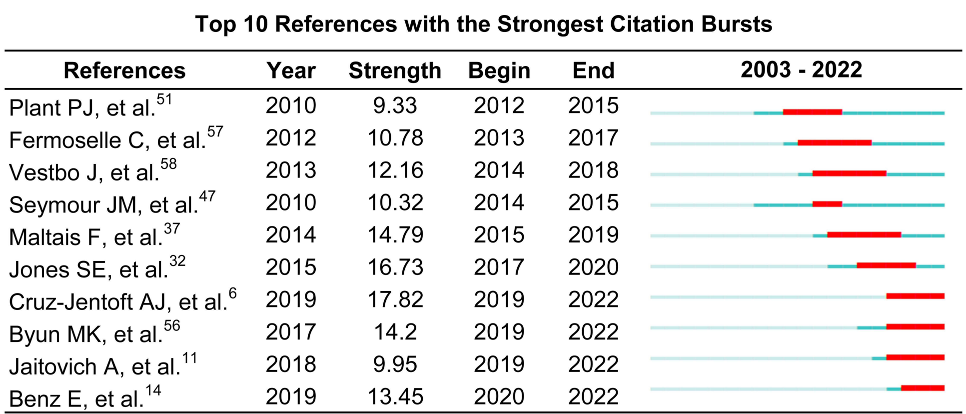


Figure 7 Visualization results of co-cited references related to COPD with sarcopenia.



Top 10 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2003 - 2022
Plant PJ, et al.[51]	2010	9.33	2012	2015	
Fermoselle C, et al.[57]	2012	10.78	2013	2017	
Vestbo J, et al.[58]	2013	12.16	2014	2018	
Seymour JM, et al.[47]	2010	10.32	2014	2015	
Maltais F, et al.[37]	2014	14.79	2015	2019	
Jones SE, et al.[32]	2015	16.73	2017	2020	
Cruz-Jentoft AJ, et al.[6]	2019	17.82	2019	2022	
Byun MK, et al.[56]	2017	14.2	2019	2022	
Jaitovich A, et al.[11]	2018	9.95	2019	2022	
Benz E, et al.[14]	2019	13.45	2020	2022	

Figure 8 Top 10 references with strongest citation bursts related to COPD with sarcopenia.

Keywords Analysis for Hotspots and Frontier Research Areas

Table 7 presents the top 20 frequent keywords related to COPD with sarcopenia. These terms such as COPD and sarcopenia represent key directions for future research. Additionally, keywords, like inflammation, frailty, exercise, rehabilitation, nutrition, malnutrition, and computed tomography, point to areas of mechanistic, diagnostic, and therapeutic investigation in the context of COPD with sarcopenia. The keyword cluster is analyzed using VOSviewer software for network visualization and overlay visualization map (Figure 9). Each keyword is represented as a circle,

Table 6 Main Content of Top 10 References with Strong Citations Bursts Related to COPD with Sarcopenia

Rank	Main Content	Strength
1	Muscle atrophy associated with COPD results from the recruitment of specific regulators of ubiquitin-mediated proteolytic pathways and inhibition of muscle growth.	9.33
2	Protein ubiquitination and loss of MyHC were enhanced only in severe COPD patients with muscle wasting, and muscle protein loss in these patients does not seem to be modulated directly by oxidative stress.	10.78
3	Global Strategy for the Diagnosis, Management, and Prevention of COPD (GOLD Executive Summary)	12.16
4	Quadriceps weakness was demonstrable in one-third of COPD patients attending hospital respiratory outpatient services and existed in the absence of severe airflow obstruction or breathlessness.	10.32
5	An Official ATS/ERS Statement: Update on Limb Muscle Dysfunction in COPD Executive Summary	14.79
6	Prevalence of sarcopenia was 14.5% in stable COPD, these patients had reduced exercise capacity, functional performance, physical activity and health status, and pulmonary rehabilitation can lead to a reversal of the syndrome in select patients.	16.73
7	Revised European consensus on definition and diagnosis for sarcopenia.	17.82
8	Systemic inflammation (Levels of circulating inflammatory biomarkers IL-6 and high-sensitivity TNFα[hsTNFα]) could be an important contributor to sarcopenia in the stable COPD population.	14.2
9	A general overview of skeletal muscle dysfunction in COPD for expert practitioners, scientists and average clinician dealing with patients with chronic respiratory diseases.	9.95
10	A systematic review and meta-analysis for sarcopenia in COPD, with varying prevalence across population settings and suggestion for using standardized tests and cut-off points to assess.	13.45

Table 7 Top 20 Keywords Related to COPD with Sarcopenia

Rank	Keyword	Count	Rank	Keyword	Count
1	Chronic obstructive pulmonary diseases	173	12	Exercise	23
2	Sarcopenia	140	13	Muscle	22
3	COPD	140	14	Pulmonary rehabilitation	21
4	Cachexia	57	15	Mortality	21
5	Skeletal muscle	52	16	Rehabilitation	18
6	Body composition	34	17	Malnutrition	18
7	Muscle wasting	33	18	Nutrition	17
8	Muscle atrophy	30	18	Muscle mass	17
9	Inflammation	29	18	Computed tomography	17
10	Frailty	25	18	Aging	17
11	Atrophy	23	18	Chronic obstructive pulmonary diseases(COPD)	17

with the circle size indicating the keyword's frequency and the line thickness reflecting the correlation between keywords (Figure 9A) The various colors of circles for keywords and lines denote hotspots and frontier research areas in recent years (Figure 9B).

Figure 9A reveals four clusters suggesting four primary research directions in the field. The red cluster encompasses cachexia, muscle atrophy or wasting, inflammation and oxidative stress. The green cluster encompasses body composition, nutrition or malnutrition, rehabilitation or pulmonary rehabilitation, and mortality. The blue cluster encompasses aging, frailty and osteoporosis. The yellow cluster encompasses computed tomography, emphysema, muscle mass. Figure 9B indicates that the yellow-green cluster represents hotspots and frontier research areas in recent years, including frailty, mortality, computed tomography and osteoporosis.

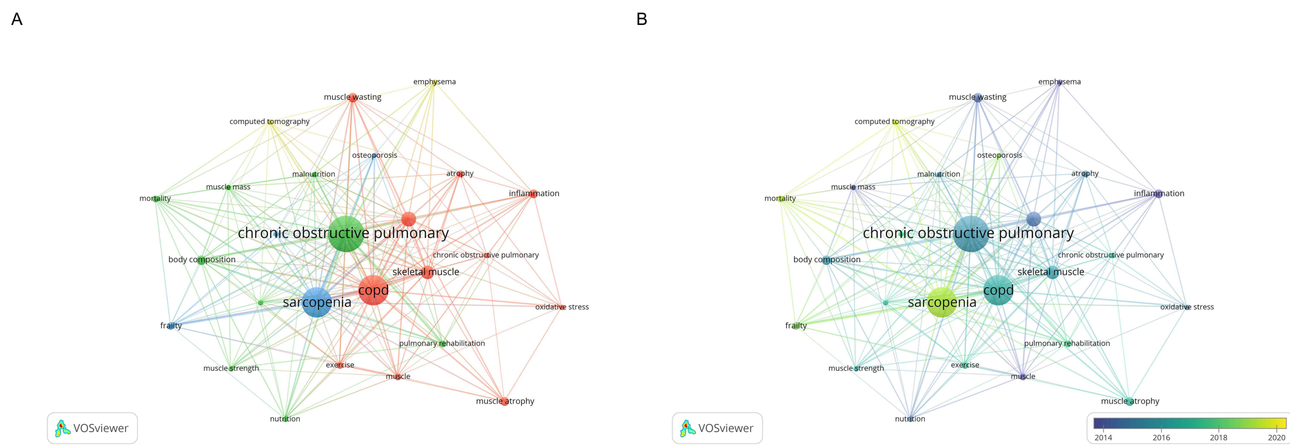


Figure 9 Cluster analysis of keywords related to COPD with sarcopenia.
Notes: (**A**) Network visualization map (**B**) Overlay visualization map for keywords.

Discussion

This study is the first scientometric analysis examining crucial findings, research focal points, and frontiers in COPD with sarcopenia. Our comprehensive review covered 758 articles and reviews. Over the past two decades, literature on COPD with sarcopenia has seen a consistent rise, notably increasing since 2013, signifying a growing emphasis on this subject. Sarcopenia, as a notable comorbidity in COPD, is poised to become a pivotal research direction in the future.

Our scientometric analysis identified the USA, Netherlands, and England as the top three countries conducting research on COPD with sarcopenia., revealing close collaboration among developed countries. Furthermore, all of the top 10 affiliations were from these developed nations, emphasizing extensive cooperation. Nearly half of the total publications focused on respiratory system, geriatrics gerontology and gerontology. Other categories indicated the common occurrence of COPD with sarcopenia alongside other diseases, emphasizing the complexity of the topic, and the necessity for comprehensive treatment.

International Journal of Chronic Obstructive Pulmonary Disease emerged as the most published journal, with notable journals like American Journal of Respiratory and Critical Care Medicine (IF=24.7, Q1) and European Respiratory Journal (IF=24.3, Q1) boasting impact factors exceeding 20. The majority of studies were published in co-cited academic journals within the Q1 region of the JCR quality, indicating their significant influence on future directions.

Current research on COPD with sarcopenia predominantly appears in two types of journals: those focusing on molecular biology and immunology and those concentrating on medicine, medical, and clinical subjects. This observation indicates increasing recognition of COPD with sarcopenia, suggesting a surge in both bench and clinical research in this field.

COPD and sarcopenia are prominent keywords, with additional terms indicating ongoing research focus and potential future areas of interest. Notably, COPD patients commonly develop skeletal muscle loss or sarcopenia, as confirmed by prior human studies.[11,59,60] Further keyword cluster analysis reveals hotspots and frontier research areas (Figure 9B), highlighted by keywords: **1) Computed tomography, frailty and mortality**. Sarcopenia, defined by low muscle strength, quantity or quality is typically assessed through bioelectrical impedance analysis (BIA), considered the gold standard for body composition measurements. Given the widespread use of chest computed tomography (CT) is widely used for lung assessment in COPD, concurrent measurement of the pectoralis muscles has emerged as a modality for sarcopenia evaluation. Validity in utilizing pectoralis muscle (PM) cross sectional area (CSA) from CT assessing skeletal muscle mass (SMM) in individuals with COPD has been established.[61] A cross-sectional study demonstrated the feasibility of CT scans to assess erector spinae muscle (ESA) size, particularly in male and obese individuals undergoing health checkups, showing a strong correlation with BIA.[62] Additionally, quantitative measurement of thoracic skeletal muscle area on chest CT scans, including CSA of PM, latissimus dorsi (LAT), and erector spinae muscle (ESM), is associated with lung function, radiologic signs of emphysema, and clinical outcomes in COPD, indicating the value of

CT-derived measurements in detecting impaired muscle quantity and quality, predicting COPD severity.[63–66] Furthermore, COPD patients undergoing lung transplant (LTx) typically experience muscle loss or sarcopenia in end-stage lung disease progression, with lean dorsal muscle area from CT scans linked to survival rate.[67] The pectoralis muscle index (PMI) and adipose tissue demonstrated by chest CT are also associated with mortality in COPD patients, including subcutaneous adipose tissue (SAT) and intermuscular adipose tissue (IMAT).[10] As reported in previous human studies, progressive COPD patients often experience pulmonary cachexia (PC),[68] and those with sarcopenia suffer adverse clinical outcomes including frailty[69–71] and mortality.[10,63,72] Physical frailty and sarcopenia exhibit extensive clinical similarities and share inflammatory biomarkers (eg IL-6), bridging the inflammation gap between COPD and sarcopenia.[73] Despite the prognostic significance of CT-body composition in COPD confirmed by the aforementioned studies, additional comprehensive research is needed due to the diverse nature of body composition assessments and clinical outcomes.[9] **2) Osteoporosis**. In the context of COPD, characterized by airflow obstruction and respiratory symptoms, patients exhibit multimorbidity. Beyond the association with muscle or sarcopenia, COPD is intricately linked to bone health, namely osteoporosis. This association amplifies the risk of fragility fractures, increases the rate of hospitalization, elevates the burden of disease, and detrimentally affects overall quality of life.[74,75] The development of osteoporosis in COPD patients is influenced by factors including corticosteroid treatment, systemic inflammation, smoke exposure, low physical activity, malnutrition, and sarcopenia.[3,74,76] Sarcopenia's presence significantly reduces bone mineral density (BMD) in mild COPD patients, and severe sarcopenia is associated with osteoporotic fractures in 9.9% of stable COPD patients,[77,78] underscoring the potential contribution of bone-muscle crosstalk to osteoporosis and sarcopenia risk in this population. Osteoporosis and sarcopenia, as common risk factors for COPD, share underlying pathogenic mechanisms. Beyond mechanical interactions, muscle and bone act as endocrine organs, regulating each other's functions.[75] Notably, IL-6, fibronectin type III structural domain-containing protein 5 (FNDC5)/irisin, myofibrillar growth factor, RANKL/RANK, and osteocalcin play potential roles in the pathogenesis of sarcopenia and osteoporosis in COPD patients. This suggests a musculoskeletal crosstalk mechanism contributing to the comorbidities in COPD.[76] Similar to the predictability of thoracic skeletal muscle CSA for sarcopenia, evidence indicates that BMD from chest CT can also serve as a convenient surrogate marker for osteoporosis, facilitating timely interventions and preventative care.[79,80] Additionally, the concept of osteosarcopenic adiposity (OSA) syndrome or osteosarcopenic obesity (OSO) has emerged, denoting the concurrent deterioration of bone (osteopenia/osteoporosis), muscle (sarcopenia), and adipose tissue expansion. This syndrome has a prevalence of 8% in middle-aged and older adults globally, with a higher burden among females and older adults.[81,82] Although the available evidence on the multilevel interactions between osteosarcopenia and COPD is summarized, further in-depth research in this area is warranted.[83] **3) Nutrition, exercise, and rehabilitation**. The evolving understanding of the relationship between sarcopenia and COPD underscores shared treatment modalities, notably nutritional support, resistance exercise (RE), and pulmonary rehabilitation (PR).[84,85] The nutritional status of COPD patients with sarcopenia emerges as a significant concern. Oral supplementation with protein, micronutrients, fat, or a combination thereof has demonstrated efficacy in enhancing muscle strength and physical performance in these individuals.[25,86] While vitamin D has received more attention in the context of bone health, the role of vitamin K, often overlooked, presents a potential link between COPD, osteoporosis, and sarcopenia, with associations noted in cross-sectional studies.[87] Muscle dysfunction and wasting stand out as prominent extra-pulmonary effects of COPD. Decreased activity leads to muscle mass reduction, culminating in inefficient oxygen utilization and establishing a detrimental cycle of exercise capacity deterioration. Presently, PR is recognized as a crucial measure to enhance lung function in COPD patients, while RE proves to be the most effective intervention for improving quality of life for sarcopenia in older people.[88,89] Further exploration of muscle-bone crosstalk in the context of nutrition and physical activity in COPD with sarcopenia holds promise for unveiling novel non-pharmacological management modalities in a condition that lacks a pharmacological cure.

Scientometric analysis serves as a descriptive and quantitative tool, offering a more evidence based assessment of the current state of research fields compared to traditional narrative commentary. In our study, we scientometricly analyzed the articles and reviews related to COPD with sarcopenia using a bibliometrics approach. The analysis, grounded in available data, furnishes comprehensive insights and trends, intending to serve as a guide for fellow researchers in the field. However, certain inherent limitations must be acknowledged. Our search was confined to the WoS Core Collection database, and we exclusively considered English literature published within the two decades. Besides, the quality of publications did not be evaluated comprehensively, with all publications contributions accorded equal weight. And VOSviewer software, employed for extracting author names and thesaurus terms for keywords, may encounter challenges when dealing with variations in spellings or multiple author names and thesaurus terms, potentially affecting the accuracy of scientometric analysis and visualization. It is imperative to recognize that while the WoS Core Collection is an authoritative and comprehensive database, and tools like VOSviewer and CiteSpace are widely used software, their utilization introduces potential biases and limitations.

In conclusion, the study provides insights into the status during the past 2 decades and research trends in the future related to COPD with sarcopenia. Statistical analysis of scientometrics holds promise in guiding future preclinical and clinical studies in the field.

Data Sharing Statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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