





# Understanding the Complexity of Hypertension with Sarcopenia by Scientometric Analysis

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**Objective:** The scientometric analysis was aim to focus on recent studies and clarify new research directions on hypertension with sarcopenia. We hope to provide comprehensive insights or actionable recommendations for clinicians or policymakers.

**Methods:** The Web of Science Core Collection database (WoSCC) from 2004 to 2023 for analysis was used. And VOSviewer, CiteSpace, and Origin software were utilized for scientometric analyses.

**Results:** The United States was the primary contributor to 1,994 studies on hypertension with sarcopenia. The University of São Paulo emerged as the most prolific institution, with Morrell Nicholas W. being the most influential scholar and Cruz-Jentoft A.J. being the most co-cited author. PLoS One was the most prolific journal, whereas Circulation was the most relevant journal. Research has focused not only on physiological, biochemical, and cell biological mechanisms but also on sarcopenia associated with other diseases and involved in various fields, highlighting the complexity of the area and the need for integrative treatment. Keyword analysis revealed that, in addition to hypertension and sarcopenia, other topics such as obesity, pulmonary hypertension, old age, metabolic syndrome, inflammation, hypoxia, exercise, insulin resistance, and revascularization attracted attention. In recent years, COVID-19, mitochondria, handgrip strength, etc. have been hot topics, but aging, skeletal muscle, weight loss, diabetes, obesity, metabolic syndrome, insulin resistance, heart failure, mitochondria, mortality, exercise, and physical activity seems to bridge hypertension and sarcopenia research.

**Conclusion:** This study highlights the distribution of fields, the structure of knowledge and the evolution of major research topics related to hypertension in patients with sarcopenia. Identifying keyword hotspots enhanced the comprehension of occurrence, development, and future research trends related to the topic.

**Keywords:** hypertension, sarcopenia, scientometric analysis, visualization

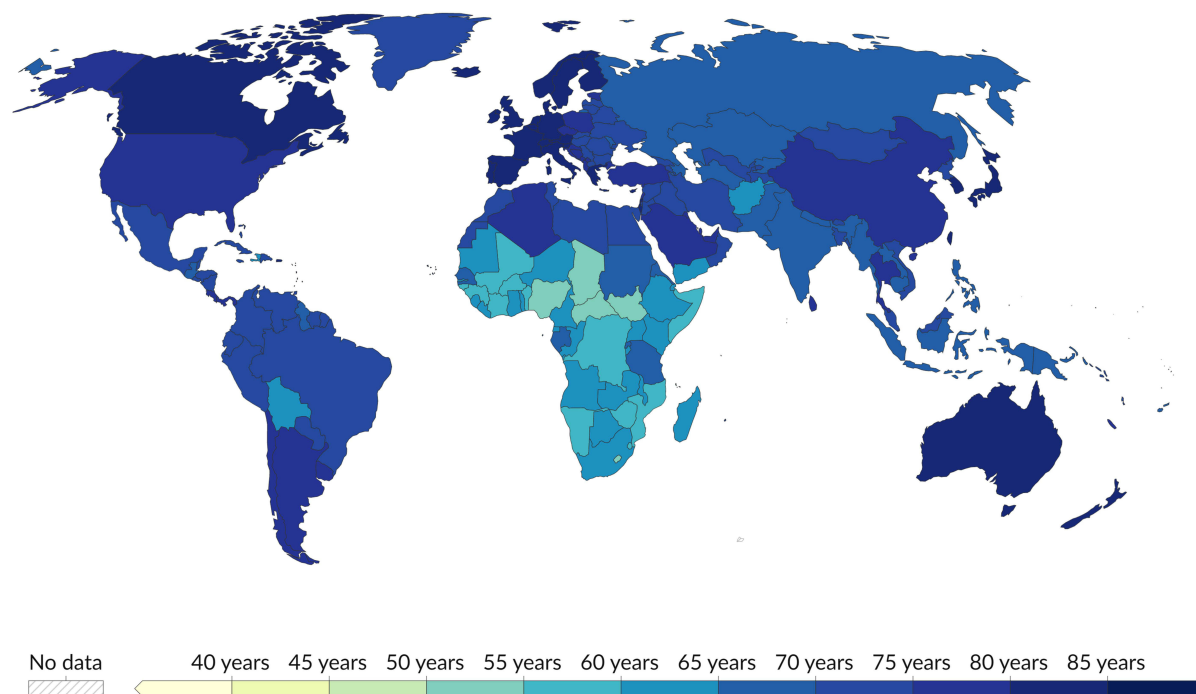
## Introduction

The average life expectancy is rising continuously as time goes on, which is aging the population (<https://ourworldindata.org/life-expectancy>) (Figure 1). An unavoidable phase of human society's growth is aging. It promotes the development of various age-related chronic conditions, such as diabetes, hypertension and sarcopenia. The number of people with hypertension would be projected to reach 1.6 billion by 2025 as a result of population aging, rising rates of obesity, and decreased physical activity. High systolic blood pressure is a leading risk factor for death worldwide, and hypertension significantly contributes to global mortality and disability, particularly among individuals aged 50 years and older.<sup>1,2</sup> Moreover, a meta-analysis highlighted the strong association between hypertension and sarcopenia in elderly individuals, with sarcopenic obesity in elderly individuals increasing this risk.<sup>3</sup>

Sarcopenia is a progressive and generalized dysfunction of skeletal muscle that commonly occurs in older people, involving the decrease in muscle strength and muscle mass or muscle quality<sup>4</sup> Despite the fact that sarcopenia has only

# Life expectancy, 2021

The period life expectancy<sup>1</sup> at birth, in a given year.



Data source: UN WPP (2022); HMD (2023); Zijdeman et al. (2015); Riley (2005)

OurWorldInData.org/life-expectancy | CC BY

**1. Period life expectancy:** Period life expectancy is a metric that summarizes death rates across all age groups in one particular year. For a given year, it represents the average lifespan for a hypothetical group of people, if they experienced the same age-specific death rates throughout their whole lives as the age-specific death rates seen in that particular year. Learn more in our article: "Life expectancy" – What does this actually mean?

**Figure 1** Latest data published by the United Nations for life expectancy in 2021.

recently been recognized clinically, this illness is critical since it is associated with a number of unfavorable health consequences, including decreased mobility, elevated morbidity, and mortality. Various definitions of sarcopenia had been commonly referenced, including those from the European Working Group on Sarcopenia in Older People updated in 2019 (EWGSOP2) and the Asian Working Group for Sarcopenia 2019 (AWGS2019).<sup>5,6</sup> A recent meta-analysis showed the prevalence of sarcopenia varied between 10% and 27% based on the classification and cut-off point employed for sarcopenia.<sup>7</sup> The literature on sarcopenia includes bibliometrics analysis and visualization analysis covering global research (including trends in nutrition research)<sup>8,9</sup> therapies (including exercise therapy),<sup>10,11</sup> and osteoporosis with sarcopenia,<sup>12</sup> as well as the relationship between muscular atrophy/sarcopenia and cardiovascular diseases in elderly individuals.<sup>13</sup> An elevated sarcopenia index was shown to be negatively associated with the risk of stroke in elderly patients with hypertension.<sup>14</sup> However, a more comprehensive scientometric analysis is not available for hypertension patients with sarcopenia.

Furthermore, the study employed CiteSpace and VOSviewer software to visualize current structures and future trends.<sup>15,16</sup> Here, by employing these techniques and building upon the existing literature and scientometric analysis, potential future research directions were proposed for hypertension with sarcopenia. We hope to provide comprehensive insights or actionable recommendations for clinicians or policymakers.

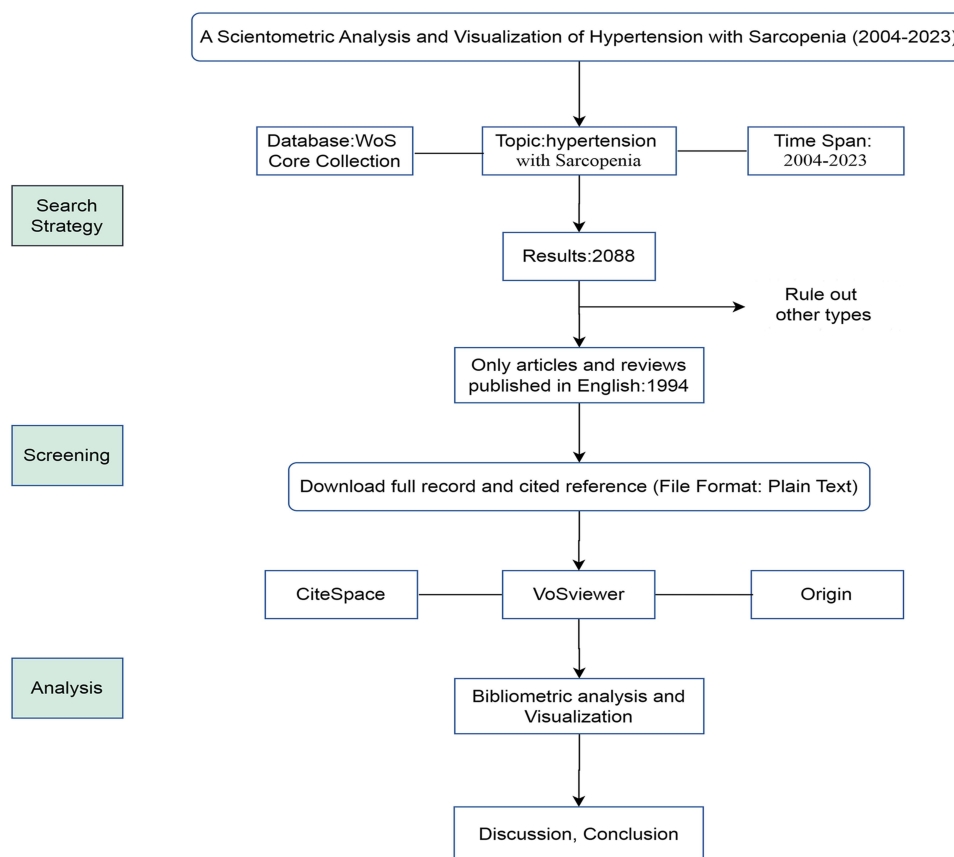
## Data and Methods

### Research Process

Compared with general databases, Web of Science stands out as the most frequently utilized database in bibliometric studies, as it contains more scientific publications and provides more comprehensive data sources. We performed a search in the WoS Core Collection (WoSCC) database on 10 March 2024 via the following terms: (TS=(Sarcopenia) OR AB=(Sarcopenia OR Sarcopenias OR Sarcopenic OR Muscle atrophy OR Muscle attenuation OR Muscle loss OR Muscle depletion)) AND (TS=(Hypertension) OR AB=(Hypertension OR High Blood Pressure)) within 2004–2023. We chose only articles and reviews that were published in English and excluded various other types of documents, including early access, book chapters, meeting abstracts, and letters. The analysis process is shown in Figure 2 plotted by Figdraw 2.0.

### Data Analysis

VOSviewer (version 1.6.19) is capable of producing three types of scientific cooperation network analysis: network visualization, overlay visualization, and density visualization. It was used to explore collaborations among countries/regions and affiliations, authors and co-cited authors, co-cited references, and keyword co-occurrences. CiteSpace (version 6.3.R1) was utilized to display the dual-map overlay and references that have significant citation bursts in the context of hypertension and sarcopenia. Origin Pro 2022 was used for managing data comprehensively, providing analytical support, and generating tables and figures. The table was enhanced with the inclusion of impact factor (IF) for journals and H-index for countries/regions to facilitate a thorough and scientific analysis.



**Figure 2** Flow chart illustrating the scientometric analysis process.

# Results

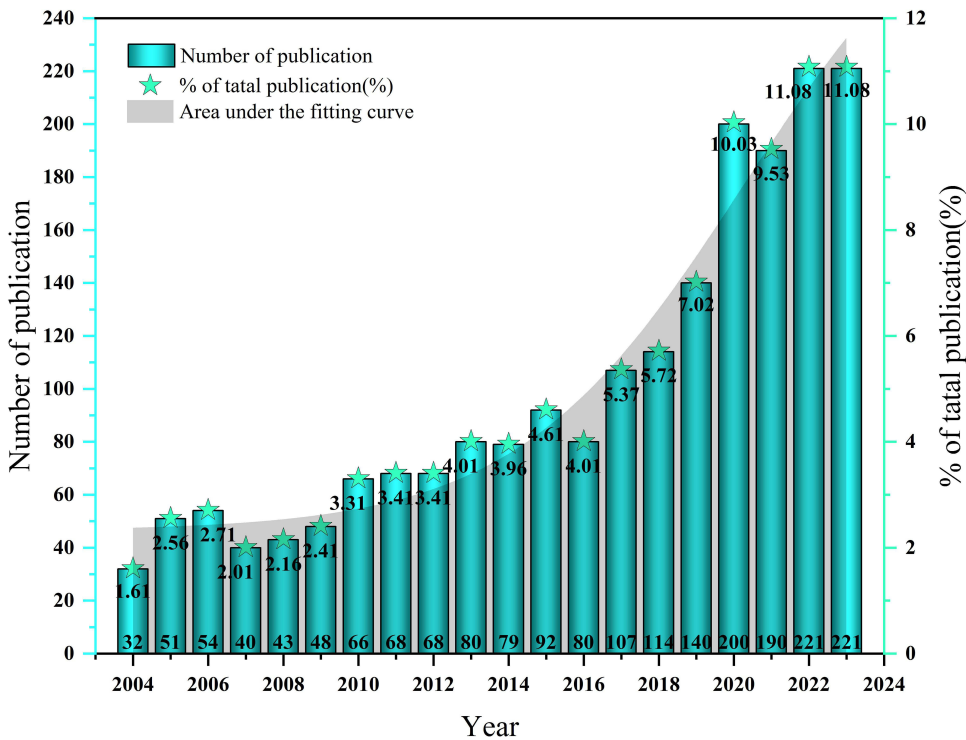
## Annual Publication Quantity

A total of 1,994 articles and reviews related to hypertension with sarcopenia were identified from 2004 to 2023. An analysis of the search results (Figure 3) clearly revealed that the annual publication output was divided into two distinct periods. The first stage, spanning a slow but steady phase from 2004 to 2016, and a rapid growth phase from 2017 to 2023, indicated an expansion with more than 100 studies per year on the subject. In general, the rate of publication has increased recently.

## Countries/Regions and Affiliations

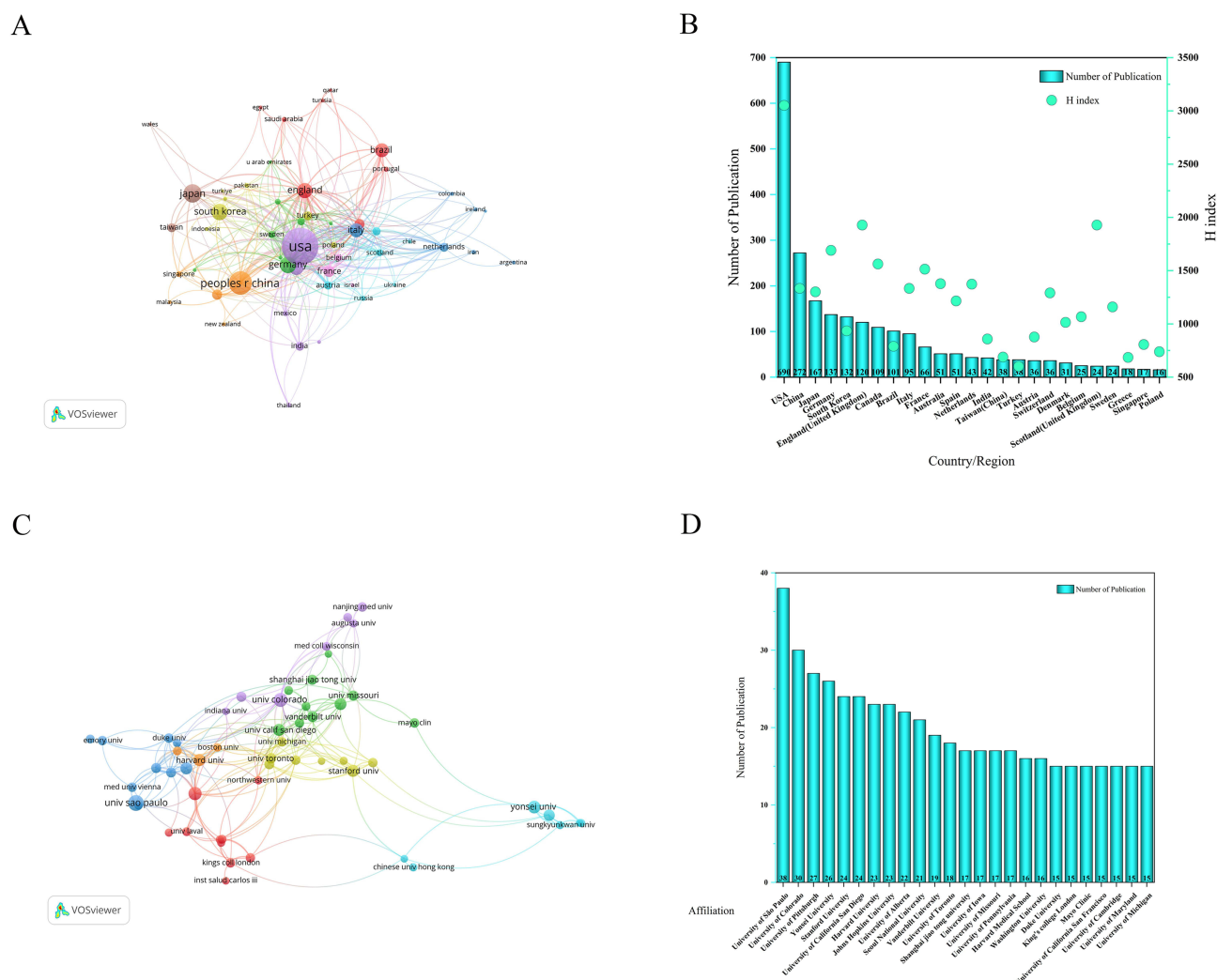
The VOSviewer network visualization map displays node size as a representation of the quantity of publications from countries/regions or affiliations. Countries or regions with frequencies greater than or equal to 5 ( $n=53$ ) and affiliations with frequencies greater than or equal to 10 ( $n=58$ ) were chosen to create a collaboration network. This network was built by analyzing the number and connections of publications from each country or region and affiliation (Figure 4A and C). The thickness of the lines that link various nodes indicates the level of collaboration or citation between projects. Authors were distributed across 92 countries/regions and 2,689 affiliations. According to Figure 4A and B, the United States was the top country with more than 600 publications ( $n=690$ , 34.60%). China, Japan, Germany, and South Korea follow, contributing to more than 1398 publications (70.11% of the total). Notably, close cooperation existed between the USA and China, the USA and Japan, the USA and Germany, and the USA and South Korea. Furthermore, the betweenness centrality of CiteSpace was used to gauge a node's significance within the network. In the context of international cooperation networks, betweenness centrality identifies countries with a purple outer ring surrounding the green nodes, playing crucial roles and holding pivotal positions in international collaboration. In this research domain (Figure 5), the top four countries by centrality were the United States (0.53), the United Kingdom (0.23), Italy (0.16), and Australia (0.11).

As shown in Figure 4C and D, University of São Paulo (Brazil) tops with 38 publications (1.91%), followed by University of Colorado (USA), University of Pittsburgh (USA), Yonsei University (South Korea), Stanford University



**Figure 3** Annual publication quantity from 2003 to 2022 related to hypertension with sarcopenia.





**Figure 4** 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.

(USA), and University of California San Diego (USA). The USA has demonstrated strong scientific capabilities in the field, as indicated by the reliability of the H-index and global rank as measures of scientific achievements and influence.

25.88% of the total publications pertained to the cardiovascular system and cardiology, geriatrics and gerontology (Figure 6). Cardiovascular disease is the leading cause of death worldwide, and the prevalence of sarcopenia is increasing with transition of the world to an aging society. Hypertension with sarcopenia has been increasingly recognized as a global health issue reflected by the following two categories: public health and health care science services. Understanding hypertension with sarcopenia requires a nuanced approach that encompasses not only pathogenesis including physiology, biochemistry molecular biology, cell biology, and research experimental medicine, but also multidisciplinary approaches, such as general internal medicine, endocrinology/metabolism, pharmacology/pharmacy, nutrition/dietetics, and sport science. This multifaceted approach facilitates the personalized management of patients. Thus, there were more physiology-related publications (10.63%), followed by general internal medicine (8.78%), biochemistry molecular biology (7.27%), and endocrinology/metabolism (7.27%). The fields of nutrition/dietetics and sport science contributed to 9.27% of the total publications, highlighting their potential therapeutic strategy in addressing the subject. Furthermore, various fields such as respiratory science and related professions have emphasized the frequent

CiteSpace, v. 6.3.R1 (64-bit) Advanced  
May 5, 2024, 9:33:00 PM CST  
WoS: G:\HBSPSP1\data  
Timespan: 2004-2023 (Slice Length=1)  
Selection Criteria: g-index (k=25), LRF=3.0, L/N=10, LBY=5, e=1.0  
Network: N=92, E=468 (Density=0.1118)  
Largest 1 CCs: 85 (92%)  
Nodes Labeled: 1.0%  
Pruning: None

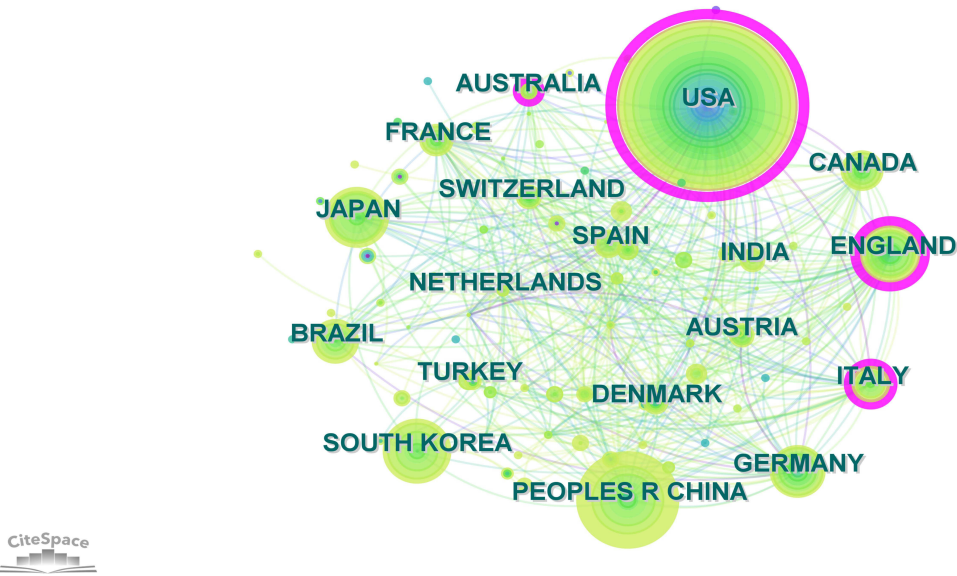


Figure 5 Map of international cooperation.

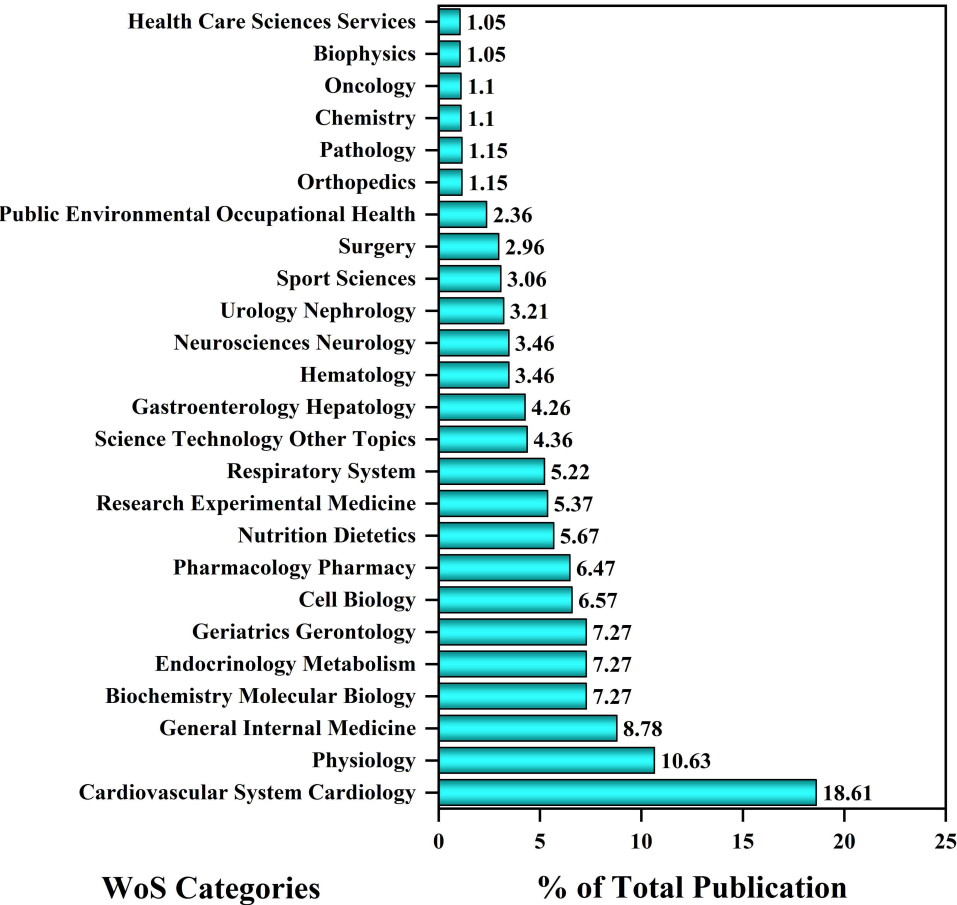


Figure 6 Research area exploration map related to hypertension with sarcopenia.

associations of sarcopenia and hypertension with other conditions, highlighting the intricate nature of the topic and the necessity for comprehensive care.

## Journals and Co-Cited Journals

Research on sarcopenia with hypertension had been published in 832 scholarly publications. Table 1 highlights the top 10 journals that PLoS ONE ranks first with 45, publications 2.26%, followed by American Journal of Physiology-Heart and Circulatory Physiology (38 publications, 1.91%) and Hypertension (38 publications, 1.91%). Notably, of the top 10 journals, 6 were based in the United States, 3 in Switzerland, and 1 in England. This list included 7 journals that are classified in the Q1 section of the JCR quartile. There were 5 journals with IFs greater than 5, including Hypertension (IF=8.3), Circulation Research (IF=20.1), Nutrients (IF=5.9), Arteriosclerosis, Thrombosis, and Vascular Biology (IF=8.7), and International Journal of Molecular Sciences (IF=5.6). Although PLoS ONE (IF=3.7) had the lowest impact factor among the top 10 journals, it still had a notable impact in the field. Notably, many articles in this area were published in journals with lower impact factors, suggesting a need for more research in this field.

Circulation was at the top with 2,508 citations according to Table 2, with Circulation Research following closely at 2,044, then Hypertension at 1,906, Journal of Biological Chemistry at 1,784, and Journal of Applied Physiology at 1,491.

**Table 1** Top 10 Journals Related to Hypertension with Sarcopenia

Rank	Number of Publication	% Total of Publication	Journal	Country/ Region	JCR Quartile	Impact Factor (2022)	H-index (2022)
1	45	2.26%	PLoS ONE	USA	Q2	3.7	435
2	38	1.91%	American Journal of Physiology - Heart and Circulatory Physiology	USA	Q1	4.8	224
3	38	1.91%	Hypertension	USA	Q1	8.3	299
4	31	1.55%	American Journal of Physiology - Lung Cellular and Molecular Physiology	USA	Q1	4.9	181
5	30	1.50%	Circulation Research	USA	Q1	20.1	385
6	28	1.40%	Frontiers in Physiology	Switzerland	Q2	4.0	158
7	24	1.20%	Nutrients	Switzerland	Q1	5.9	209
8	23	1.15%	Arteriosclerosis, Thrombosis, and Vascular Biology	USA	Q1	8.7	292
9	22	1.10%	Scientific Reports	United Kingdom	Q2	4.6	315
10	18	0.90%	International Journal of Molecular Sciences	Switzerland	Q1	5.6	269

**Table 2** Top 10 Cited Journals Related to Hypertension with Sarcopenia

Rank	Citation	Cited Journal	Country/ Region	JCR Quartile	Impact Factor (2022)	H-index (2022)
1	2508	Circulation	USA	Q1	37.8	674
2	2044	Circulation Research	USA	Q1	20.1	385
3	1906	Hypertension	USA	Q1	8.3	299
4	1784	Journal of Biological Chemistry	USA	Q2	4.8	556
5	1491	Journal of Applied Physiology	USA	Q2	3.3	260
6	1307	Journal of Clinical Investigation	USA	Q1	15.9	544
7	1272	PLoS ONE	USA	Q2	3.7	435
8	1266	American Journal of Physiology - Heart and Circulatory Physiology	USA	Q1	4.8	224
9	1168	Proceedings of the National Academy of Sciences of the United States of America	USA	Q1	11.1	869
10	1036	New England Journal of Medicine	USA	Q1	158.5	1184

It was worth mentioning that there were 7 journals in the top Q1 section of the JCR quartile, as well as 6 journals with impact factors exceeding 5. These include *Circulation* (IF=37.8), *Circulation Research* (IF=20.1), *Hypertension* (IF=8.3), *Journal of Clinical Investigation* (IF=15.9), *Proceedings of the National Academy of Sciences of the United States of America* (IF=11.1), and the *New England Journal of Medicine* (IF=158.5). Compared to the journals mentioned above, the top co-cited journals were predominantly from the United States and demonstrated a significant increase in the impact factor (IF). This emphasized the fact that the research had a solid theoretical foundation and also reflected the leadership of the USA in the field again.

The visualized analysis of the dual-map overlay of journals revealed the shared citation relationships among different fields of journals via CiteSpace software. The primary application paths are indicated by the yellow and green lines, with the citing journal on the left and the cited journal on the right. The yellow lines indicate research articles published in journals focused on molecular, biology, and immunology, with primary citations located in molecular, biology, and genetics journals and health nursing, and medicine journals. The green lines indicate research articles published in journals focused on medicine, medical, and clinical, with primary citations located in molecular, biology, and genetics journals, and health, nursing, and medicine journals (Figure 7). In addition, as shown in the right ellipse, the most citations were found in journal named *Circulation*, with its vertical axis indicating the highest number of published articles and the horizontal axis indicating the highest number of authors.

## Authors and Co-Cited Authors

A total of 12,153 authors were found in the publications, and a collaboration network was established with authors who published at least 5 papers (n=68). Table 3 highlights the top two authors with 10 papers at least. Morrell Nicholas W led with the publication count (n=14). Among the 58,951 co-cited authors, 6 received more than 100 citations in relevant publications. The highest number of co-citations (n=326) belonged to Cruz-Jentoft AJ, followed by Chen LK (n=147) and Janssen I (n=136).

## Cited Articles and Co-Cited References

Based on the result of publications identified in the WoSCC (Table 4), 7 of the 1,994 publications were cited more than 500 times.<sup>17–26</sup> Among the top 10 cited articles, most focused on pathogenesis and prognosis. In the field, a total of 86,194 co-cited references were identified. Table 5 shows that the top 10 references commonly cited together in relation to hypertension and sarcopenia had a minimum of 38 co-citations.<sup>5,6,27–35</sup> Among the top 10 co-cited references, most focused on the definition and diagnosis of sarcopenia.

## References with Citation Bursts

The top 10 references showing the most significant citation increases are listed in the Table 6, and the primary research content was condensed. As listed, the citation burst duration was from 2012 to 2023.<sup>4–6,29,31,33,34,36–38</sup> Among these references, the consensus of sarcopenia by EWGSOP2 exhibited the strongest citation burst with a strength of 23.58, which appeared from 2019 to 2023. In a word, the burst strength of the leading 10 sources ranged between 5.09 and 23.58, lasting from 2 to 3 years.

## Keywords Analysis

Top 20 frequent keywords related to the field are shown in Table 7. These terms such as sarcopenia, hypertension and blood pressure represent frontier research areas. Additionally, keywords, such as obesity, aging, metabolic syndrome, inflammation, hypoxia, oxidative stress, insulin resistance, angiotensin ii, and exercise, highlighted aspects of mechanistic, diagnostic, and therapeutic investigations related to hypertension with sarcopenia. The keyword cluster was analyzed via VOSviewer software for network visualization and overlay visualization map (Figure 8).

As shown in Figure 8A, every keyword was depicted as a circular shape, with four clusters indicating the four main areas of research in the field. The crimson group included hypertension, pulmonary hypertension, and blood pressure. The green group included sarcopenia, body composition, and frailty. The blue cluster encompassed obesity, metabolic

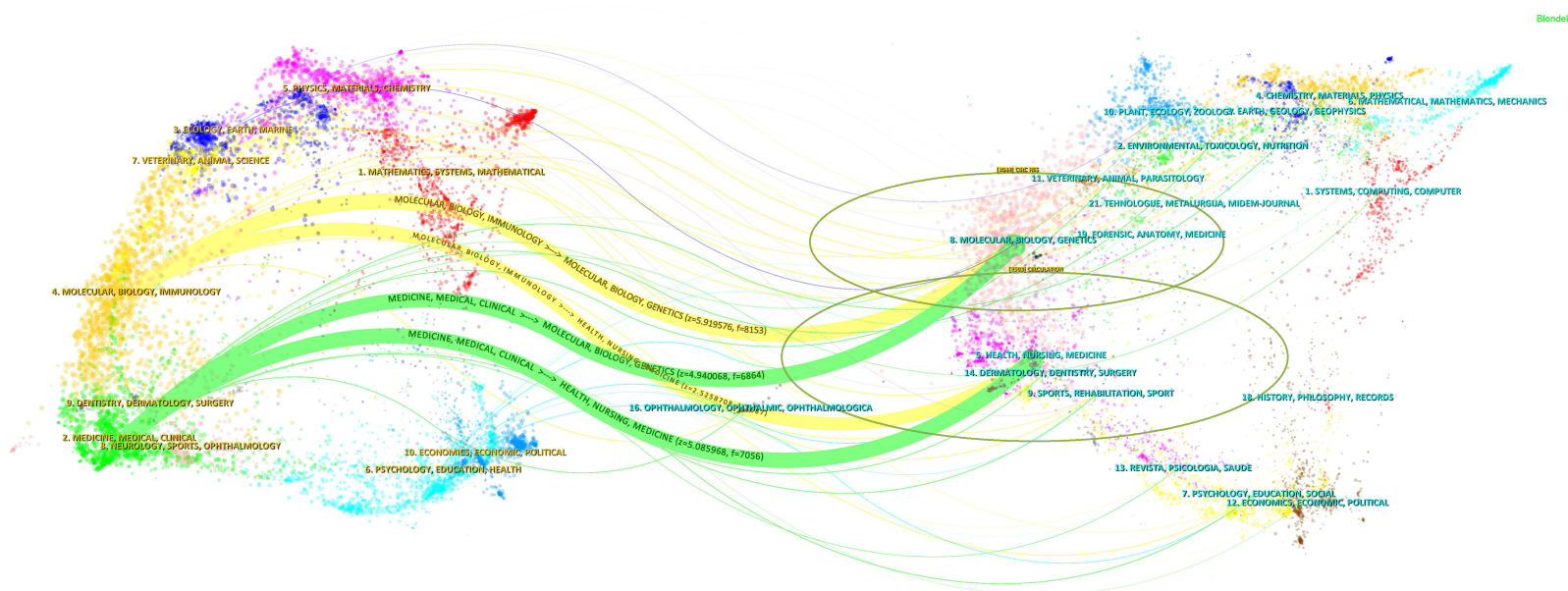


Figure 7 Dual-map overlay depicting journals related to hypertension with sarcopenia.

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

Rank	Author	Count	Rank	Co-cited Author	Citation
1	Morrell Nicholas W.	14	1	Cruz-Jentoft A.J.	326
2	Wang Jian	10	2	Chen L.K.	147
3	Klemm Dwight. J.	9	3	Janssen I.	136
4	Wang Lingli	9	4	Humbert M.	115
5	Bonnet Sebastien	8	5	Baumgartner R.N.	101
6	Kwapiszewska Grazyna	8	6	Morley J.E.	101
7	Provencher Steeve	8	7	Stenmark K.R.	99
8	Rabinovitch Marlene	8	8	Wang J.	89
9	Seeger Werner	8	9	Archer S.L.	87
10	Weissmann Norbert	8	10	Montano-loza A.J.	87

**Table 4** Top 10 Cited Articles Related to Hypertension with Sarcopenia

Rank	Citation	The Title of Article	Year	Cited Journal	Country/Region	JCR Quartile	Impact Factor (2022)	H-index (2022)
1	1436	Lack of Exercise Is a Major Cause of Chronic Diseases. <sup>17</sup>	2012	Comprehensive Physiology	USA	Q1	5.8	121
2	1317	Pathophysiology of Sleep Apnea. <sup>18</sup>	2010	Physiological Reviews	USA	Q1	33.6	388
3	878	Adult obstructive sleep apnoea. <sup>19</sup>	2014	Lancet	United Kingdom	Q1	168.9	895
4	734	Vascular calcification - Pathobiological mechanisms and clinical implications. <sup>20</sup>	2006	Circulation Research	USA	Q1	20.1	385
5	623	The endocrine function of adipose tissue: an update. <sup>21</sup>	2006	Clinical Endocrinology	United Kingdom	Q3	3.2	165
6	557	Dynapenia and Aging: An Update. <sup>22</sup>	2012	Journals of Gerontology - Series A Biological Sciences and Medical Sciences	United Kingdom	Q1	5.1	221
7	525	The vascular smooth muscle cell in arterial pathology: a cell that can take on multiple roles. <sup>23</sup>	2012	Cardiovascular Research	United Kingdom	Q1	10.9	244
8	451	Synthetic cannabinoids: Epidemiology, pharmacodynamics, and clinical implications. <sup>24</sup>	2014	Drug and Alcohol Dependence	Ireland	Q2	4.2	187
9	437	Sarcopenia and mortality risk in frail older persons aged 80 years and older: results from the SIRENTE study. <sup>25</sup>	2013	Age and Ageing	United Kingdom	Q1	6.7	168
10	405	Associations of grip strength with cardiovascular, respiratory, and cancer outcomes and all cause mortality: prospective cohort study of half a million UK Biobank participants. <sup>26</sup>	2018	BMJ-British Medical Journal	United Kingdom	Q1	107.7	497

syndrome, and insulin resistance. The yellow group included aging, inflammation, and atherosclerosis. As shown in Figure 8B, the yellow-green group highlighted key research topics and emerged areas of interest in recent years, such as handgrip strength, older individuals, COVID-19, and diabetes mellitus.



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

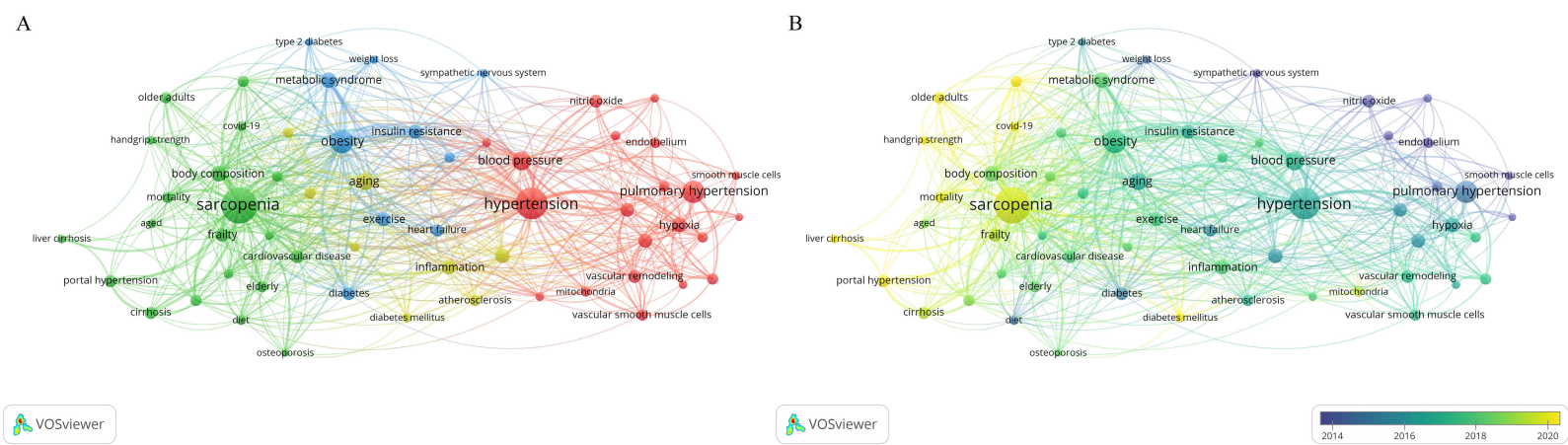
Rank	Citation	The Title of Reference	Author	Year	Journal	DOI
1	145	Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. <sup>33</sup>	Cruz-Jentoft A.J.	2010	Age and Ageing	10.1093/ageing/afq034
2	104	Sarcopenia: revised European consensus on definition and diagnosis. <sup>5</sup>	Cruz-Jentoft A.J.	2019	Age and Ageing	10.1093/ageing/afy169
3	76	Sarcopenia in Asia: Consensus Report of the Asian Working Group for Sarcopenia. <sup>34</sup>	Chen L.K.	2014	Journal of the American Medical Directors Association	10.1016/j.jamda.2013.11.025
4	60	Asian Working Group for Sarcopenia: 2019 Consensus Update on Sarcopenia Diagnosis and Treatment. <sup>6</sup>	Chen L.K.	2020	Journal of the American Medical Directors Association	10.1016/j.jamda.2019.12.012
5	59	Frailty in older adults: Evidence for a phenotype. <sup>27</sup>	Fried L.P.	2001	Journals of Gerontology - Series A Biological Sciences and Medical Sciences	10.1093/gerona/56.3.m146
6	53	Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. <sup>28</sup>	Janssen I.	2002	Journal of the American Geriatrics Society	10.1046/j.1532-5415.2002.50216.x
7	52	The FNIH Sarcopenia Project: Rationale, Study Description, Conference Recommendations, and Final Estimates. <sup>29</sup>	Studenski S.A.	2014	Journals of Gerontology - Series A Biological Sciences and Medical Sciences	10.1093/gerona/glu010
8	51	Epidemiology of sarcopenia among the elderly in New Mexico. <sup>30</sup>	Baumgartner R.N.	1998	American Journal of Epidemiology	10.1093/oxfordjournals.aje.a009520
9	39	Sarcopenic Obesity: Prevalence and Association With Metabolic Syndrome in the Korean Longitudinal Study on Health and Aging (KLoSHA). <sup>31</sup>	Lim S.	2010	Diabetes Care	10.2337/dc10-0107
10	38	Heterozygous germline mutations in BMPR2, encoding a TGF- $\beta$ receptor, cause familial primary pulmonary hypertension. <sup>32</sup>	Lane K.B.	2000	Nature Genetics	10.1038/79,226
10	38	Molecular regulation of vascular smooth muscle cell differentiation in development and disease. <sup>35</sup>	Owens G.K.	2004	Physiological Reviews	10.1152/physrev.00041.2003

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

Rank	Reference	Year	Strength	Begin-End	DOI	Main content
1	Cruz-Jentoft AJ,et al <sup>33</sup>	2010	8.01	2012–2015	10.1093/ageing/afq034	Sarcopenia: European consensus on definition and diagnosis
2	Lim S,et al <sup>31</sup>	2010	5.66	2013–2015	10.2337/dc10-0107	Sarcopenic obesity defined by ASM/VVt was more closely associated with metabolic syndrome than either sarcopenia or obesity alone in the Korean Longitudinal Study on Health and Aging (KLoSHA)
3	Courboulin A,et al <sup>38</sup>	2011	5.34	2013–2016	10.1084/jem.20101812	Uncover a new regulatory pathway involving miR-204 that is critical to the etiology of human pulmonary arterial hypertension
4	Nisbet RE,et al <sup>37</sup>	2010	5.09	2013–2015	10.1165/rcmb.2008-0132OC	Rosiglitazone attenuates chronic hypoxia-induced pulmonary hypertension in a mouse model
5	Chen LK,et al <sup>34</sup>	2014	12.44	2016–2019	10.1016/j.jamda.2013.11.025	Sarcopenia in Asia: Consensus Report of the Asian Working Group for Sarcopenia
6	Studenski SA,et al <sup>29</sup>	2014	10.35	2016–2019	10.1093/gerona/glu010	The Foundation for the National Institutes of Health Sarcopenia Project: Rationale, study description, conference recommendations, and final estimates
7	Cruz-Jentoft AJ,et al <sup>5</sup>	2019	23.58	2021–2023	10.1093/ageing/afy169	Revised European consensus on definition and diagnosis for sarcopenia
8	Chen LK,et al <sup>6</sup>	2020	18.74	2021–2023	10.1016/j.jamda.2019.12.012	Asian Working Group for Sarcopenia: 2019 consensus update on sarcopenia diagnosis and treatment
9	Cruz-Jentoft AJ,et al <sup>4</sup>	2019	8.75	2021–2023	10.1016/S0140-6736(19)31138-9	Narrative review of sarcopenia
10	Batsis JA,et al <sup>36</sup>	2018	5.98	2021–2023	10.1038/s41574-018-0062-9	Sarcopenic obesity in older adults: aetiology, epidemiology and treatment strategies

**Table 7** Top 20 Keywords Related to Hypertension with Sarcopenia

Rank	Keyword	Count	Rank	Keyword	Count
1	Sarcopenia	278	11	Oxidative stress	45
2	Hypertension	215	12	Exercise	44
3	Obesity	117	13	Frailty	43
4	Pulmonary hypertension	109	14	Insulin resistance	43
5	Blood pressure	81	15	Angiotensin II	40
6	Aging	68	16	Pulmonary arterial hypertension	40
7	Body composition	55	17	Vascular remodeling	39
8	Metabolic syndrome	55	18	Cardiovascular disease	38
9	Inflammation	48	19	Diabetes	36
10	Hypoxia	47	20	Nitric oxide	35



**Figure 8** Cluster analysis of keywords related to hypertension with sarcopenia.  
**Notes:** (A) Network visualization map (B) Overlay visualization map for keywords.

## Discussion

To the best of our knowledge, this is the first scientometric analysis study to review important discoveries, areas of research interest, and research frontiers related to hypertension with sarcopenia. The study covered 1,994 articles and reviews on hypertension with sarcopenia. The number of Publication in the field has consistently increased over the past two decades, notably since 2017, signifying the growing recognition and importance of this field in both academia and clinical practice.

Visualizing the international collaboration network by using countries as nodes allowed us to gain clear insight into the positions occupied by various countries within this domain. The research we conducted identified the USA, China, and Japan as the leading countries, and the top four countries in terms of betweenness centrality—the United States, the United Kingdom, Italy, and Australia—were all developed countries. They not only had a high volume of publications in this field, but also contributed significantly to international collaborations, facilitating the dissemination of information and the flow of resources. Notably, among the top 25 affiliations, the majority were from the USA, with extensive cooperation between other countries. Nearly one-quarter of the total publications focused on the following categories: cardiovascular system cardiology, geriatrics and gerontology. In the meantime, different categories suggested that other illnesses were alongside in patients of hypertension with sarcopenia, underscoring the intricacy of the subject and the necessity of a comprehensive treatment approach.

PLoS ONE emerged as the most published journal and *Circulation Research* boasted an IF exceeding 20 as the most notable journal. The majority of research papers were released in academic co-cited journals in the Q1 region of the JCR quality, demonstrating their notable impact on upcoming developments. Currently, studies on this topic are published in two kinds of journals. One category was focused on molecular biology and immunology, whereas the other focused on medicine, medical, and clinical subjects. These findings suggest that hypertension with sarcopenia is gaining recognition and the research may be experiencing a burst.

Hypertension and sarcopenia were among the most common keywords, and other keywords represented the current research direction and future interests. Notably, prior studies confirmed that hypertension patients are associated with increased risk of sarcopenia at least 2 times.<sup>39</sup> Cluster analysis revealed the hotspots and frontier research areas bridged by keywords (Figure 8B):

## Aging

Sarcopenia is a skeletal muscle disorder and age is a known contributor to sarcopenia. Significant correlations between sarcopenia/severe sarcopenia and older Chinese adults have also been reported in other studies.<sup>40,41</sup> Aging is recognized as a risk factor for hypertension. The relative contributions of the sympathetic and parasympathetic nerve systems to the regulation of women's blood pressure can change as they age.<sup>42</sup> In addition, sympathetic nerves play a role in the generation of blood pressure waves in young and old people.<sup>43</sup> In fact, the number of people over 60 will grow worldwide in the next few years, contributing to the social burden of sarcopenia and hypertension (Figure 1).

## Skeletal Muscle, and Weight Loss

The definition of sarcopenia has evolved to focus on the loss of muscle strength.<sup>44</sup> In addition to its role in mobility, skeletal muscle is also acknowledged as a secondary secretory organ through the release of myokines via extracellular vesicles. These myokines possess endocrine functions that impact numerous systems within the body, thus contributing to overall health preservation.<sup>45–47</sup> Furthermore, angiotensin II can induce skeletal muscle atrophy.<sup>48</sup> Metabolic parameters deteriorate with low muscle mass transition, increasing the hazard ratios for type 2 diabetes mellitus (T2DM), hypertension, and metabolic syndrome (MetS). Implementing timely interventions during this transitional phase can effectively mitigate the occurrence of unfavorable events associated with reduced muscle mass.<sup>49</sup>

## Diabetes, Obesity, MetS, and Insulin Resistance

Hypertension is an important component of MetS, along with diabetes, obesity, and dyslipidemia. China's diabetic population is indeed the largest in the world, accounting for a quarter of the world's diabetic population, with 114 million

people(<https://www.statista.com/topics/6556/diabetes-in-china/#topicOverview>).<sup>50</sup> Growing evidence has demonstrated that sarcopenia is more prevalent in patients with T2DM than in the normal population and is considered one of the chronic complications in patients with T2DM.<sup>51,52</sup> Sarcopenic obesity is defined by low muscle mass and rising fat accumulation simultaneously.<sup>53</sup> Regardless of gender, people who are overweight or obese have a high prevalence of sarcopenia, and this condition appears to be linked to an increased risk of T2DM.<sup>54</sup> A cross-sectional study revealed a strong correlation between obesity and hypertension, but not between sarcopenia and hypertension, or between sarcopenic obesity and hypertension.<sup>55</sup> Nonetheless, a narrative review demonstrated the tight relationship between hypertension and sarcopenic obesity, sharing similar variables including oxidative stress, insulin resistance, and inflammation.<sup>56</sup>

## Heart Failure, Mitochondria and Mortality

One of the main risk factors for heart failure is hypertension. Nevertheless, diabetes, obesity, and MetS, all have a significant impact on the development of heart failure. An impaired nutritional status is commonly observed in hospitalized patients with decompensated heart failure. This condition is typified by the presence of dietary deficits and sarcopenia, which may eventually lead to cachexia. Patients with diabetes mellitus (DM) and chronic heart failure (CHF) usually have decreased muscle mass.<sup>57</sup> Renin-angiotensin system activation may also play a role in the development of muscle wasting in CHF patients with diabetes mellitus, in addition to malnourishment and a decrease in plasma insulin levels. Patients with CHF who have diaphragm weakness exhibit substantial intrinsic functional and ultrastructural abnormalities in their mitochondria.<sup>58</sup> However, in contrast to the diaphragm, which is always in use, the majority of the catabolic alterations in heart failure rats have been shown in the soleus or gastrocnemius muscles.<sup>59</sup> The first indications of skeletal muscle impairment were found to be mitochondrial dysfunction and myostatin up-regulation. In addition, the study demonstrated that there is an independent link between peripheral artery disease and muscle wasting in heart failure patients.<sup>60</sup> A study revealed that sarcopenia is a significant contributing factor for increased mortality ( $p = 0.022$ ) and reduced survival rates ( $p = 0.033$ ) in patients with heart failure II–IV class by the NYHA.<sup>61</sup> In patients with heart failure, muscular sympathetic nerve activity (MSNA) can also be the most accurate indicator of weight loss; nevertheless, body weight loss alone does not indicate poor outcomes.<sup>62</sup>

## Exercise and Physical Activity

Sarcopenia leads to a decline in physical performance. A systematic review encompassing 68 research totaling 98,502 cases revealed that physical inactivity is a behavioral component linked to sarcopenia in older persons living in the community.<sup>63</sup> Research has shown the effectiveness of exercise alone or in conjunction with dietary changes to improve physical performance and muscle strength.<sup>64</sup> Due to a reduction in immune cell infiltration into perivascular adipose tissue, exercise training has been demonstrated to enhance vascular structure and function in hypertension in both the peripheral circulation and the major arteries.<sup>65</sup> In other words, individuals with a sedentary lifestyle experience an excess of nutrients, leading to fat accumulation and disruption of adipocyte metabolism. This imbalance in adipocyte metabolism results in the secretion of primarily proinflammatory cytokines known as adipokines. In contrast, during skeletal muscle contraction, myokines are released and serve to counteract these proinflammatory cytokines.<sup>46</sup>

Scientometrics analysis can offer a more detailed and quantitative examination compared to traditional narrative commentary, offering stronger evidence on the current state of the research field. Using a bibliometrics technique, we conducted a scientometric analysis of the reviews and publications pertaining to hypertension and sarcopenia in the study. Based on the available data, our analysis can offer comprehensive insights and trends to guide other researchers in the field. Future researchers who are interested in hypertension and sarcopenia should collaborate with universities in the US, and they are recommended to refer to Morrell's and Cruz-Jentoft's prior publications. People who are performing further studies on hypertension with sarcopenia need to pay more attention to physiological, biochemical, and cell biological mechanisms. But there are several limitations inevitably: we only searched the WoS Core Collection database. Only English literature published within the last 20 years had been taken into account. And VOSviewer software automatically extracts the author's name and thesaurus term for keywords, using different spellings or multiple names and thesaurus term, and it may not be extracted correctly or be influenced in scientometric analysis and visualization. Despite the

widespread use of VOSviewer and CiteSpace software, as well as the authoritative nature of the WoS Core Collection database, these limitations could introduce bias. We currently know that hypertension and sarcopenia act together in skeletal muscle, but the exact mechanism of action is unclear. There is a need for more preclinical and clinical studies in the future, which could draw more attention to the field from peers.

## Conclusion

In summary, the study sheds light on the state of research on hypertension with sarcopenia during the previous 20 years as well as future directions in this area. Early monitoring, management, and exercise instruction are essential for the elderly population of sarcopenia with multiple comorbidities (obesity, hypertension, and diabetes, etc). Future preclinical and clinical research in the field could benefit from the guidance provided by the scientometric analysis.

## Data Sharing Statement

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

## Acknowledgments

We express our gratitude to all the researchers who took part in the study related to hypertension with sarcopenia.

## 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.

## Funding

There is no funding to report.

## 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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