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Global Scientific Trends in Research Related to Diabetic Sarcopenia from 1993 to 2023: A Bibliometric Analysis

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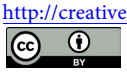

Abstract

Objectives: In this study, bibliometric approach was used to explore the literature in the field of research related to Diabetic Myasthenia Gravis in order to identify the current research progress in Diabetic Myasthenia Gravis related research and to help the researchers to predict the future hotspots in the field of research and to provide reference for the research. **Methods:** Literature related to diabetic sarcopenia published from 1993 to 2023 since the inception of the repository was extracted from the Web of Science Core Collection (WoSCC) and bibliometric analyses were performed. We have analysed the published literature of the last approximately almost 30 years, as well as publication and citation analyses from different countries, institutions, journals and authors. For keywords, we performed co-occurrence, clustering, timeline view and citation burst analysis. **Results:** On the basis of 1564 publications, we found a continuous increase in the number of publications and citations, especially in the last six years. The United States is the most representative country, and Seoul National University (SNU) is the most representative institution. The most popular journal in the field is Diabetes Care; Fukui, Michiaki is the most prolific author, leading many studies related to diabetic sarcopenia. The most frequently cited reference was a revised European consensus on the definition and diagnosis of sarcopenia; the most cited keywords were related to physiological factors of diabetes, sarcopenia and related conditions, such as "insulin resistance", "skeletal muscle", "body composition", "risk" and "prevalence". **Conclusion:** With more and more studies on the relationship between diabetic sarcopenia, this study presents the current status and trend of research related to diabetic sarcopenia over the past nearly 30 years through the visualization software CiteSpace. It can help researchers identify potential collaborators and partner institutions, hotspots and research frontiers in the field of diabetic sarcopenia. However, our work is only

based on the English language literature in the WoSCC database, and for future studies, we recommend that researchers explore the literature from multiple databases to enhance the scope of their research.

Keywords

Diabetes, Sarcopenia, Bibliometrics, Research Trends, Citespace

1. Introduction

Diabetes mellitus is a common chronic disease with a growing global prevalence [1]. Approximately 537 million adults worldwide had diabetes in 2021, and that number is expected to rise to 643 million by 2030 and 783 million by 2045 [2]. Diabetes mellitus is a metabolic disorder caused by impaired insulin secretion and increased insulin resistance, and the vast majority of cases are type 2 diabetes mellitus (T2DM). Many studies have found a strong relationship between diabetes and sarcopenia. Sarcopenia was firstly proposed by Rosenberg in 1989, sarcopenia is a group of low cognitive and high morbidity diseases, the prevalence of sarcopenia varies from 5.5% to 25.7% in various regions [3], clinically defined as a progressive skeletal muscle disease, type II fibre dominated by muscle fibre atrophy, reduced motor unit number and muscle Type II fibre-based muscle fibre atrophy, reduced number of motor units and intramuscular fat accumulation are the main pathological features. With the global ageing of the population, sarcopenia has become a common condition in the elderly, which significantly increases the risk of falls, disability and death [3]. Studies have shown that the prevalence of sarcopenia in 60 - 70 year olds ranges from 5% to 13%, while >80 years of age can be as high as 11% to 50%, and it is predicted that the number of people with the disease may be as high as 500 million by 2050 [4], and sarcopenia has become a global public health problem [5]. The elderly are at high risk of sarcopenia due to ageing, and skeletal muscle is important for systemic glucose metabolic homeostasis. A recent Korean cross-sectional study suggests that sarcopenia is an independent influence on metabolic syndrome in middle-aged and elderly populations [6]. It has been shown that sarcopenia has become an independent risk factor for T2DM [7]. There is also evidence of an interaction between sarcopenia and T2DM [8]. Diabetes mellitus and sarcopenia often occur in combination and interact in a vicious circle: diabetes mellitus hyperglycaemia and insulin resistance cause myosin catabolism to exceed myosin synthesis, which leads to loss of muscle mass, which in turn leads to an imbalance in the function of glucose metabolism in skeletal muscle, which exacerbates insulin resistance, and which leads to an increase in the amount of muscle mass. Relevant studies have shown that patients with T2DM have a 55% increased risk of developing sarcopenia compared to non-T2DM patients [9]. Although there are more and more scientific researches on diabetes mellitus, such

as the incidence of diabetes mellitus in the population, the pathogenesis, and the connection between the two. However, there is a lack of authoritative statements and scientific guidelines on whether diabetes affects sarcopenia first, or whether sarcopenia affects diabetes first, or whether the two affect each other at the same time, and there is a lack of research on the development trend and hotspots of sarcopenia, which fails to provide scientific guidance for researchers in this field. Bibliometrics is a method of analysis that provides a comprehensive perspective or quantitative parametric analyses of an entire field of research or of a specific scientific application [10] [11] [12]. In this study, CiteSpace software was used to visualise and analyse the literature on diabetic sarcopenia published in the past 30 years, to understand the currentstatus and research hotspots, and to help guide future research directions.

2. Sources and methods

2.1. Literature Search and Screening

We searched the literature from WoSCC for analysis. The search strategy is "((TS = ("Diabetes" OR "diabetic" OR "Type 2 diabetes")) AND ((TS = (Sarcopenia)) OR TS = (patients with sarcopenia)))". This search was carried out on 25 November 2023.The study included research papers and reviews published since the establishment of the library until 25 November 2023 (1993-2023). Article exclusion criteria are: 1) Articles from books, conference abstracts, letters, conference proceedings, editorial materials, etc. 2) Articles in non-English languages.The screening process is shown in **Figure 1**.

2.2. Research Tools

The main research tool for this paper is the Citespace software developed by Dr

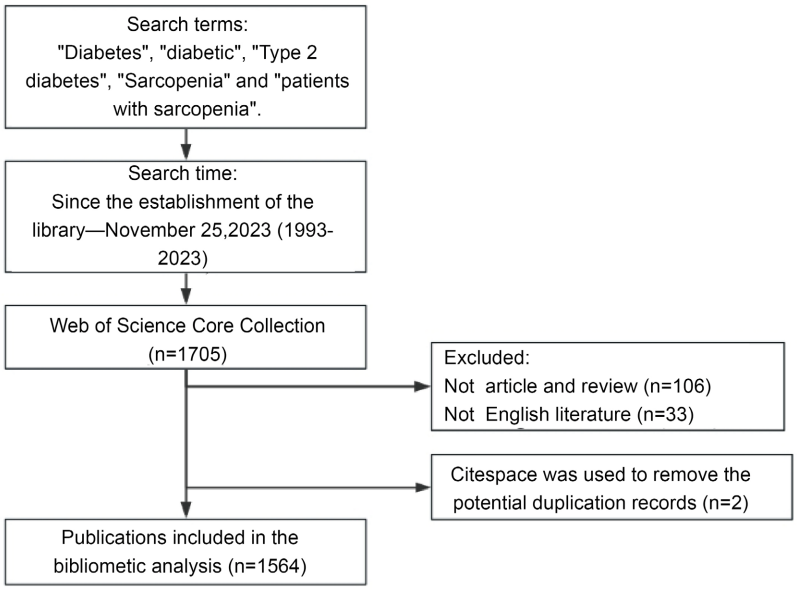

Figure 1. The screening process of the selected literature in this study.

Chao-Mei Chen of Drexel University, USA. This is an information visualisation software developed in Java language, which can be used to measure the collection of literature in a particular field in order to identify the critical path of the development of the discipline, and to analyse the evolution and development frontiers of the discipline by drawing a series of visual maps [13] [14].

2.3. Methods of Analysis

The English literature information retrieved and screened in WoSCC was exported in the form of full records and plain text of the references used, and the files were named with the beginning of download, and saved into the pre-established folders respectively. Different countries, institutions, authors, cited journals, cited literature, keywords (co-occurrence, clustering, timeline, outbreaks) were visualised and analysed using the Citespace, V. 6.2.R2 software, with the time zones spanning 1993-2023 and the time nodes set to 1year to generate the visualisation maps.

3. Results

3.1. Publication Volume Analysis

We analyzed the annual publication volume from the year of library construction to 2023 by Citespace and imported it into Excel to generate a line graph, as shown in **Figure 2**. The time trend analysis showed that the first article on sarcopenia was published by Evans W J *et al*. [15] in 1993 with the title "sarcopenia and age-related changes in body composition and functional capacity". From 1993 to 2023, the number of publications increased from 1 per year to 238 per year. 1993-2007, the number of publications was relatively low; 2007-2015, the number of publications increased slowly, indicating that the study of diabetes sarcopenia gradually attracted the attention of researchers; 2015-2023, the number of publications increased particularly rapidly, with an average of 1 per year. The number of articles increased particularly rapidly, with an average increase of 26 articles per year, indicating that the research in this field has been highly valued by researchers at this stage.

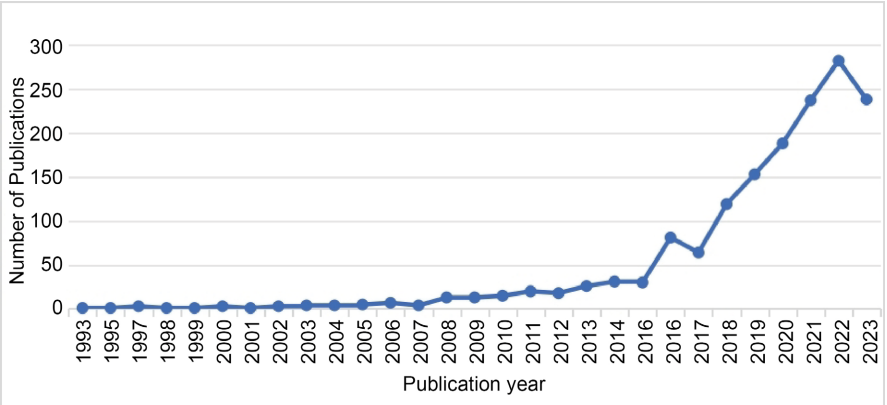

Figure 2. Annual number of published articles from 1993 to 2023.

3.2. Distribution Analysis of Countries and Institutions

The Country of 1564 documents was visualised and analysed by Citespace and Figure 3 was obtained. All the literature included was from 69 countries. The data in the upper left corner of the figure show that "N = 75, E = 407, Density is 0.1467", where "N" stands for nodes, and the size of the nodes represents the number of articles issued, and the larger the size of the country's name, the more articles are issued. "E" stands for the line between nodes, representing the connection between countries, the thicker the line, the more cooperation between authors of countries. Of these countries, the United States (n = 382) had the most publications, followed by Japan (n = 266), China (n = 230), South Korea (n = 174) and England (n = 100), with the United States of America far outstripping the others in terms of the number of articles sent, as shown in Table 1. By visualising and analysing the institutions, a total of 473 institutions were involved in this research area, as shown in Figure 4. According to the data in the upper left corner of the graph, "N = 473, E = 1323, Density is 0.0119". Among them, the top five institutions in terms of the number of publications were Seoul National University (SNU) (n = 39), Kyoto Prefectural University of Medicine (n = 38), Yonsei University (n = 35), University of London (n = 25), and Seoul National University Hospital (n = 25), as shown in Table 1.

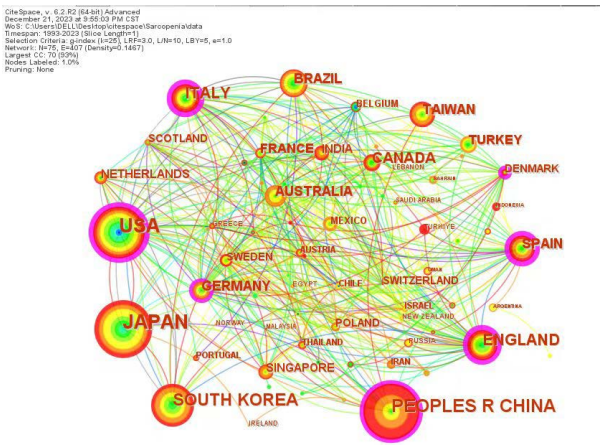

Figure 3. National co-occurrence map of studies related to diabetic sarcopenia from 1993 to 2023.

Table 1. Number of relevant publications for the top five countries and institutions.

Rank	Publication	Country	Publication	Institution
1	382	USA	39	SNU
2	266	Japan	38	Kyoto Prefectural University of Medicine
3	230	China	35	Yonsei University
4	174	South Korea	25	University of London
5	100	England	25	Seoul National University Hospital

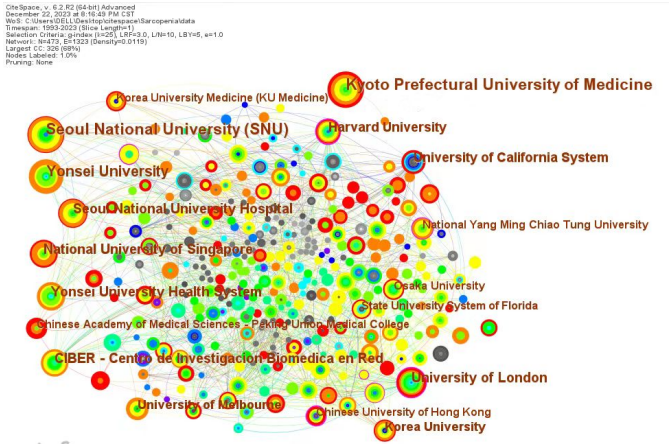

Figure 4. Institutional map of studies related to diabetic sarcopenia from 1993 to 2023

3.3. Analysis of Authors and Cited Authors

The authors of these 1564 documents were analysed by Citespace and 659 nodes (N) and 1339 connectors (E) were obtained, as shown in **Figure 5**. It shows a total of 1,339 articles published by 659 authors.The top five authors were Fukui, Michiaki (n = 36), Hamaguchi, Masahide (n = 35), Hashimoto, Yoshitaka (n = 32), Okamura, Takuro (n = 28) and Yamazaki, Masahiro (n = 25) as shown in **Table 2**. Fukui, Michiaki and Hamaguchi, Masahide have a similar research focus on influencing factors [16]-[21], pathogenesis [22] [23] [24] [25], and prevalence [26], and there are many collaborations betweenthem. The distribution of cited authors is shown in **Figure 6**. Cruz-Jentoft AJ had the highest frequency of citations (662), followed by Chen LK (357), Park SW (258), Janssen I (239) and Morley JE (238), as shown in **Table 2**. **Figure 6** shows that only Janssen I and Baumgartner RN have purple rings, indicating that the centrality of all other cited authors is <0.1.

3.4. Journals and References Are Co-Cited for Analysis

Journal co-citation analysis mainly focuses on analysing the correlation and similarity between journals, and the influence of journals depends on the co-citation frequency of journals, which reflects the influence of journals in a specific research field. Journal co-citation analysis of 1564 articles through Citespace is shown in **Figure 7**. At K = 10, 420 nodes (N) and 3820 connectors (E) were generated with a Density of 0.0432, and the connectors between the nodes indicated co-citation relationships. As can be seen from the figure, only one purple ring appears in these nodes, indicating the overall low centrality of these cited journals. Diabetes Care was the most frequently cited journal, followed by Journals of Gerontology Series A-biological Sciences And Medical Sciences (J Gerontol A-Biol), Plos One, Age Ageing, and J Am Med Dir Assoc. Eighty per cent of the top five co-cited journals were medical journals with high impact factors, as shown in **Table 3**.

Table 2. Top five authors and cited authors.

Rank	Publication	Author	Citedfrequency	Cited author	Centrality
1	36	Fukui, Michiaki	662	Cruz-Jentoft A J	0.09
2	35	Hamaguchi, Masahide	357	Kyoto Prefectural University of Medicine	0.04
3	32	Hashimoto, Yoshitaka	258	Yonsei University	0.09
4	28	Okamura, Takuro	239	University of London	0.14
5	25	Yamazaki, Masahiro	238	Seoul National University Hospital	0.08

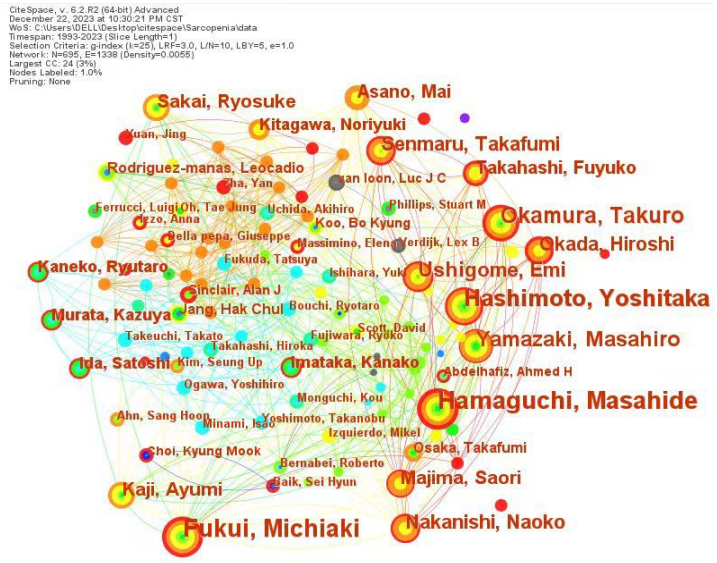

Figure 5. Author map of studies related to diabetic sarcopenia from 1993 to 2023.

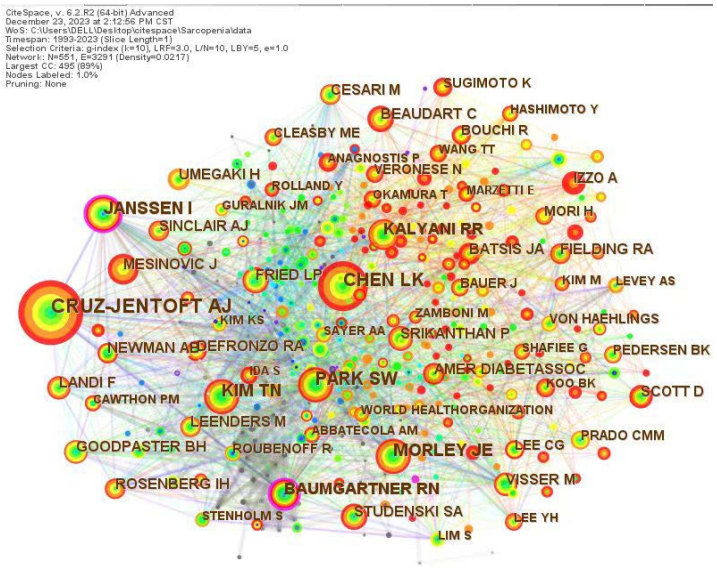

Figure 6. Map of cited authors of studies related to diabetic sarcopenia from 1993 to 2023.

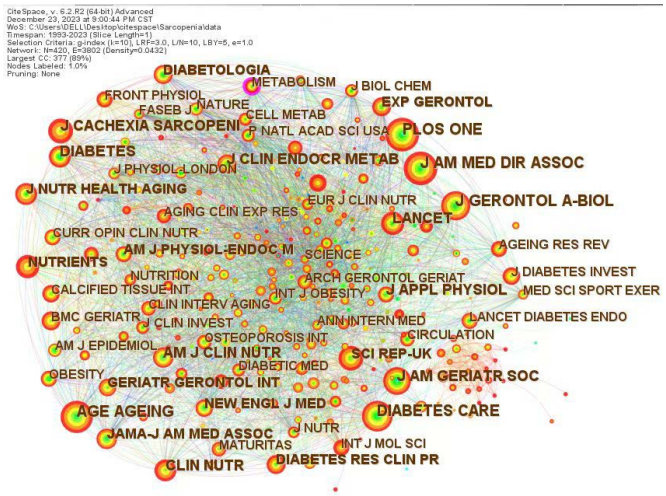

Figure 7. Journal citations from studies related to diabetic sarcopenia from 1993 to 2023.

Table 3. The top five cited journals.

Rank	Cited frequency	Journal	Impact Factor	Centrality
1	808	Diabetes Care	16.2	0.03
2	805	J Gerontol A-Biol	5.1	0.06
3	770	Plos One	3.7	0.03
4	764	Age Ageing	6.7	0.04
5	727	J Am Med Dir Assoc	7.6	0.01

Figure 8 shows the co-citation graph of the cited references, which generates 846 nodes (N) and 3289 connectors (E) with a Density of 0.0092 at K = 10. These two articles describe the revision of the previous European consensus on the definition and diagnosis of sarcopenia by the European Working Group on sarcopenia in Older People (EWGSOP) and the update of the 2019 consensus on the diagnosis and treatment of sarcopenia by the Asian Working Group on sarcopenia, respectively. The third and fourth references detail the bidirectional relationship between sarcopenia and type 2 diabetes mellitus [8], the pathophysiological dissection of current treatment options for sarcopenia, and the future potential for disease prevention [27]. The fifth cited document was sarcopenia in Asia: Chen LK's consensus report of the Asian sarcopenia working group published in 2014 [28]. The top five co-cited documents are shown in **Table 4**. As a result, there is no uniform definition and diagnostic criteria for sarcopenia, and the relationship between diabetes mellitus and sarcopenia is slowly being studied.

3.5. Keyword Analysis

3.5.1. Keyword Co-Occurrence Analysis

Keywords can fully summarise the content of the article and reflect the focus of

Table 4. The top five cited literatures.

Rank	Cited frequency	Reference
1	268	Sarcopenia: revised European consensus on definition and diagnosis
2	145	Asian Working Group for Sarcopenia: 2019 Consensus Update on Sarcopenia Diagnosis and Treatment
3	116	Sarcopenia and type 2 diabetes mellitus: a bidirectional relationship
4	87	Sarcopenia
5	238	Sarcopenia in Asia: Consensus Report of the Asian Working Group for Sarcopenia

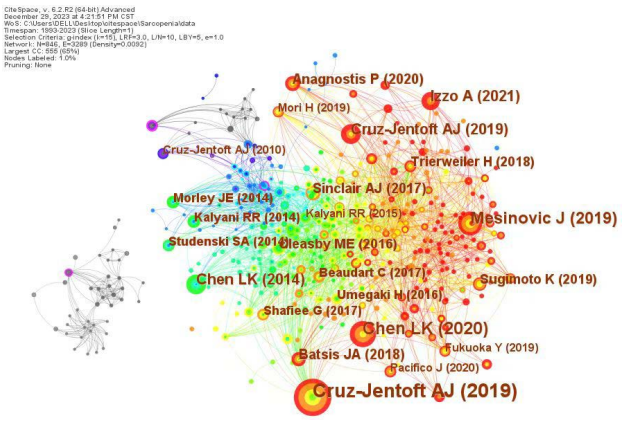

Figure 8. The literature on diabetic sarcopenia from 1993 to 2023 was cited.

the research field, while the keyword frequency distribution can reflect the research basis and current status of the research topic [29]. The keywords of 1564 articles were analysed for co-occurrence by Citespace, and **Figure 9** was obtained. At K = 10, 453 nodes (N) and 3726 connectors (E) were generated with a Density of 0.0364. The most frequently occurring keyword was sarcopenia, followed by insulin resistance, skeletal muscle, body composition, risk. Body composition had the highest centrality of 0.22. The first 10 keywords and their centrality are shown in **Table 5**. Insulin resistance and muscle mass are the focus of concern for people with diabetic sarcopenia. Therefore, the ultimate goal of any study is to improve physical functioning in patients with diabeticsarcopenia.

3.5.2. Keyword Clustering and Timeline Graph Analysis

Cluster mapping focuses on reflecting structural features between clusters, and keyword clustering improves the accuracy of summarising research areas. Through the keyword clustering function of CiteSpace, **Figure 9** was clustered to obtain the keyword clustering map in **Figure 10**. The Q-value of keyword clustering is 0.3143 > 0.3 and S-value is 0.6833 > 0.5, which indicates that the structure of clustering out is significant and the clustering is efficient and meaningful.A total of 8 clusters were identified in the cluster analysis, namely #0 skeletal muscle, #1 prevalence, #2 muscle atrophy, #3 c reactive protein, #4 insulin resistance, #5 heart failure, #6 cardiovascular, #7 t cells. The timeline view focuses on

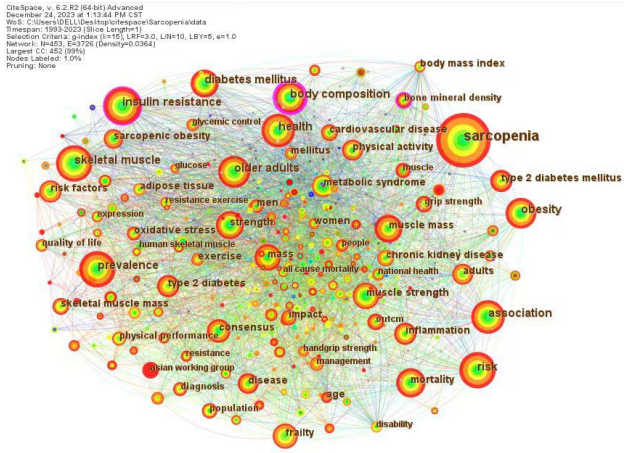

Figure 9. Keyword co-occurrence map of studies related to diabetic sarcopenia from 1993 to 2023.

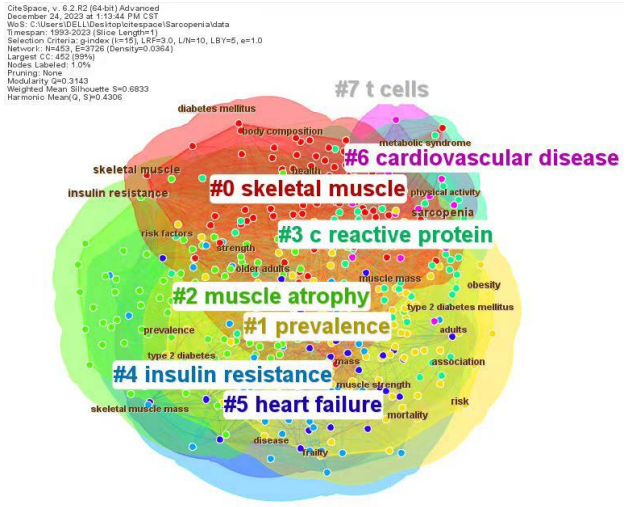

Figure 10. Keyword cluster map of studies related to diabetic sarcopenia from 1993 to 2023.

Table 5. Top 10 keywords and their centrality.

Rank	Keyword	frequency	centrality
1	sarcopenia	513	0.07
2	insulin resistance	309	0.1
3	skeletal muscle	302	0.07
4	body composition	238	0.22
5	risk	237	0.04
6	prevalence	232	0.01
7	older adults	230	0.01
8	health	218	0.02
9	association	193	0.02
10	diabetes mellitus	189	0.06

the relationships between clusters and the historical span of keywords in a particular cluster [30], see **Figure 11**. The size of the nodes indicates the frequency of occurrence, and the lines between the nodes indicate the 2 keywords present in the same article or articles. From the timeline chart, "skeletal muscle" and "prevalence" appeared earlier, while "muscle atrophy" and "heart failure" are the most recent studies, and "prevalence" has continued to be a hot research topic.

3.5.3. Keyword Emergence Analysis

The emergent keywords are generated using CiteSpace mutation word detection technology, which can show that the keywords are used significantly more often in a certain period of time, and the keywords with citation frequency indicate that the specific keywords have a high citation rate in a specific period of time, which reveals the hotspots of research in a certain research area in a specific period of time [31]. Among the 25 emergent words shown in the results (**Figure 12**), the strongest emergent word is "metabolic syndrome", which was produced in 2009, "asign working group" and "protein synthesis" are the hot spots and research trends in recent years. It is also evident that the consensus on the diagnostic criteria for sarcopenia has been continuously researched and updated, and that research on sarcopenia has become more in-depth, with multidisciplinary co-operation from pathophysiology and other disciplines.

4. Discussion

4.1. Overview

The high prevalence of diabetes mellitus and sarcopenia has become a cause of heavy social and economic burden [32] [33] [34]. In this study, we analysed the development of diabetic sarcopenia, as well as research hotspots and future trends.

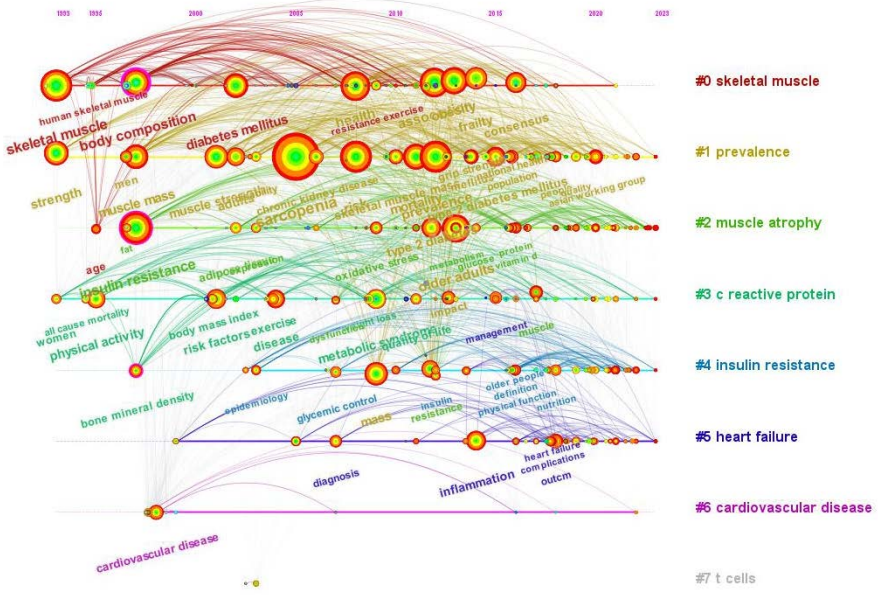

Figure 11. Keyword time map of studies related to diabetic sarcopenia from 1993 to 2023.

Figure 12. Key words outburst map of studies related to diabetic sarcopenia, 1993-2023.

Our findings indicate that publications in this area are growing rapidly and that the United States is now the leader in this field. According to our study, the hot topic of research in this field is the etiology of sarcopenia, and the representative key words are "insulin resistance", "skeletal muscle", "body composition" and "prevalence". This study provides systematic guidance and potential research directions for researchers in this field.

4.2. Principal Findings

Evans W J equalled the first published study of the symptoms and possible factors influencing sarcopenia in 1993 [15]. In the later period, the number of publications was sparse from 1993 to 2007, and showed a slow increase from 2007 to 2015, indicating that studies related to diabetes mellitus oligomerization gradually attracted the attention of researchers during this period. The growth in the number of publications from 2015 to 2023 has been particularly rapid, with an average growth of 26 papers per year, indicating that research in this area is highly valued by researchers at this stage. We hypothesise that there may be two

reasons for this, firstly, after the publication of the European Consensus on Definition and Diagnosis of sarcopenia by EWGSOP in 2010 [35] and the consensus report of the Asian sarcopenia working group by Chen LK in 2014 [28], more and more researchers have conducted in-depth studies on sarcopenia. For example, Woo J compared the criteria published by the European Working Group on Sarcopenia in the Elderly, the International Sarcopenia Task Force, and the Foundation for the National Institutes of Health (FNIH) with the Asian Sarcopenia Task Force Consensus Group Definition to explore the feasibility of applying the diagnostic criteria for sarcopenia published by different regions to populations in different regions [36]; Umegaki H [37] also published articles on the topic of hyperglycaemia as a risk factor for age-related decline in muscle mass and function, among others.

Of the relevant articles published worldwide, the United States published 276, or about 17.6 percent of the 1564 articles selected, indicating that the United States is a leader in this field. In terms of citations, the American journal "Diabetes Care" topped the list with 808 citations, indicating that the literature published in the United States is authoritative and reliable in the field of diabetic sarcopenia. On this basis, there is still great potential for research in this area in other countries. The quality of articles published in this area is relatively good, with 20 percent of the top five journals overall coming from the Q1 quartile, 60 percent from the Q2 quartile and 20 percent from the Q3 quartile. The top 5 journals with the most publications were Diabetes Care, J Gerontol A-Biol, Plos One, Age Ageing and J Am Med Dir Assoc.

In summary, most of the papers in these journals are about elderly patients, diabetes, and medicine in general, which is the broad area in which diabetic sarcopenia is located. However, the mechanism of correlation or bi-directionality between diabetic sarcopenia has not been fully elucidated, and there is still much room for research in the relationship between diabetic sarcopenia bi-directionally, and even the co-morbidity of these two with other diseases is also a research trend [38] [39] [40] [41] [42].

4.3. Research Hot Spots and Development Trends

Combined with literature analysis and keyword co-occurrence analysis, it seems that the relationship between sarcopenia and age has been inextricably linked since 1993 when Evans W J published an article entitled "Sarcopenia and age-related changes in body composition and functional capacity" [15]. In 2005, Kaysen G A published an article entitled "Diabetes, a cause of progressive sarcopenia in dialysis patients?", which for the first time brought the conjecture of a link between diabetes and sarcopenia to the public eye [43]. With the release of the European Consensus on the Definition and Diagnosis of Sarcopenia [35] in 2010 and the publication of the Asian Sarcopenia Working Group Consensus Report [28] in 2014, the research on diabetic sarcopenia has become more and more extensive and in-depth, and the number of publications has shown rapid

growth. Current research in this area is centred on four main areas: 1) The elderly are the main population with diabetes and sarcopenia. Short K R *et al*. [44] have shown that muscle mass tends to decrease with this age. A study by Kalyani R R *et al*. [45] also indicated that hyperglycaemia accelerates the rate of muscle strength loss with age. 2) Diabetes and the pathogenesis of sarcopenia.T2DM is usually associated with insulin resistance [46], accumulation of advanced glycosylation end-products, oxidative stress [8], inflammatory response [47], hyperglycaemic toxicity and increased lipotoxicity [48], which interfere with normal cellular functioning and result in impaired protein anabolism leading to sarcopenia. With the development of sarcopenia, which further leads to an increase in adiposity and inflammatory factors such as TNF-α in the body, the risk of developing T2DM increases [49]. Muvhulawa N *et al*. [50] who showed that high-sensitivity C-reactive protein, interleukin-6 and tumour necrosis factor-alpha, which are independently associated with deterioration of muscle function and sarcopenia in T2DM, emphasised the importance of strengthening intracellular antioxidant systems to maintain muscle mass, strength and function in patients with T2DM. Bouchi R *et al*. [51] human study also showed that studying insulin therapy attenuates the loss of muscle mass, reduces the incidence of sarcopenia or alleviates the symptoms of sarcopenia in Japanese patients with type 2 diabetes mellitus. 3) Co-morbidity of diabetic sarcopenia with other diseases. The results of related studies suggest that diabetes mellitus and sarcopenia are associated with debilitating, obesity, cardiovascular disease, stroke and other [38] [39] [40] [41] [42] diseases, although the relevant pathways of action have not been fully explained. E.g., Boonpor J [52] study says screening and prevention of sarcopenia in patients with type 2 diabetes may help prevent cardiovascular disease complications. Sinclair A J [53] showed that the decline in muscle mass, strength and function associated with diabetes leads to sarcopenia, weakness and ultimately disability, and that weakness mediates the pathogenesis of disability in older people with diabetes.

In conclusion, the present study was a bibliometric analysis of studies related to diabetic sarcopenia over a period of almost 30 years. At present, research in the field of diabetic sarcopenia has received extensive attention and some satisfactory results have been achieved. However, there is a lack of authoritative guidelines on the treatment of diabetic sarcopenia in terms of its pathogenesis, and researchers are continuing their work in this area, which will provide us with more effective guidance.

5. Strengths and Limitations

This is the first bibliometric analysis of the research in the field of diabetic sarcopenia, which can provide scientific information, predict research hotspots and research trends, summarize the current status of research in this field, and further promote the development of this field. However, this paper only included the literature from one database and only analyzed the literature published in

English, which may affect the prediction of research hotspots. Multi-center and large-sample studies can be carried out in the future to deepen the understanding of this field and actively explore the preventive and countermeasure measures.

6. Conclusion

This study was based on CiteSpace software to analyse data from the literature related to diabetic sarcopenia included in WoSCC. The clear and intuitive knowledge map truly and objectively presents the current research status and comparative analysis of its research hotspots and development trends, which is conducive to the rapid prediction of potential future research dynamics. Sixty-nine countries are currently involved in this area of research, which has developed rapidly in recent years. The United States and Seoul National University are representative countries and institutions, and Fukui, Michiaki is a pioneer in this field. Through the analyses, in the future, we should continue to pay attention to the progress of related research in other countries and strengthen the cooperation among countries, institutions and authors to promote the development of related research.

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Conflict of Interest

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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