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REVIEW

A Systematic Bibliometric Analysis of Cardiovascular Disease Risk in Obesity (2014–2024)

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Background: Obesity, as a global chronic disease, is causing an increasing risk of cardiovascular disease. This study used bibliometrics to synthesize and analyze publications related to obesity and cardiovascular risk from 2014 to 2024. It aimed to clarify the current status of research, predict future trends, and provide a scientific basis for prevention and treatment.

Methods: In this study, we used bibliometrics online analysis platform, Citespace (version 6.3.R1, LLR algorithm) and VOSviewer (version 1.6.20) software to analyze the co-occurrence network analysis of publications related to cardiovascular risk of obesity in worldwide for countries, institutions, authors, and journals from January 2014 to September 2024, and keyword co-occurrence, clustering, and burst analysis were performed to reveal research trends and hotspots.

Results: A total of 1492 articles related to cardiovascular risk in obesity were selected for this study, and in terms of the number of publications showed a steady increase over time. Based on keyword clustering analysis, the field can be summarized into two research themes: the field of the relationship between health indicators such as BMI, waist circumference, cardiovascular disease, and the field of metabolism and obesity-related issues. According to the keyword burst analysis, the keywords cholesterol, oxidative stress, non-alcoholic fatty liver disease, and ratio to height became prominent and will be the main research hotspots in the future.

Conclusion: In recent years, there has been a rapid increase in cardiovascular risk research in obese patients. This article reveals the remarkable progress and dynamic trends in this field, providing strong support for exploring new directions, as well as laying a data foundation for public health policy development and interdisciplinary collaboration. Future research should prioritize focusing on mechanism exploration and clinical application of novel drugs to promote health improvement.

Keywords: obesity, cardiovascular disease, risk, bibliometric study, knowledge mapping

Introduction

Obesity is a chronic disease caused by excessive absorption or intake of nutrients resulting in excessive accumulation of fat in the body, and the body mass index (BMI) > 30 kg/m^2 has been internationally defined as obesity. In recent years, with the improvement of dietary structure and standard of living, the prevalence of obesity has also increased significantly, posing a serious threat to public health worldwide.[1,2] According to the statistics of the World Health Organization (WHO), there are approximately 650 million obese adults globally. At the current rate of growth, it is projected that more than 1 billion people will suffer from obesity by 2025.[3] Obesity not only diminishes quality of life and increases the risk of non-communicable diseases such as hypertension and diabetes, but also imposes a massive medical and economic burden. Rough estimates suggest that obesity accounts for over $700 billion annually in healthcare costs globally, with the United States alone incurring approximately $100 billion per year.[4] In Western countries, the economic cost of obesity treatment accounts for 8.2–8.7% of total healthcare costs.[5]

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Obesity is strongly associated with cardiovascular disease (CVD). Studies have shown that CVD and cancer are particularly prominent causes of death in patients with obesity.[6] CVD is a common and serious threat to human health, primarily affecting the heart and blood vessels. In 2022, the WHO reported that nearly one-third of global deaths are directly attributable to cardiovascular or vascular disease, leading to an estimated 17.9 million deaths annually.[7] Recent epidemiological studies have shown that obesity is an independent risk factor for the development of CVD.[8,9]

Notably, the role of Visceral Adipose Tissue (VAT) in obesity-related cardiovascular risk has received widespread attention in recent years. VAT not only serves as a site of fat storage but is also directly involved in the onset and progression of CVD through the secretion of various inflammatory factors and metabolites. A recent study[10] demonstrated that VAT is closely associated with residual cardiovascular risk in obese patients through the modulation of inflammatory response, insulin resistance, and lipid metabolism. These findings reveal the key pathological mechanisms of VAT in obesity-related cardiovascular diseases and enhance our understanding of its role. Meanwhile, a study[11] highlights that accurate assessment of cardiovascular risk is crucial for developing personalized treatment plans, especially in obese patients. The study emphasizes that control of low-density lipoprotein cholesterol (LDL-C) levels is one of the key factors in reducing cardiovascular risk, which provides valuable insights for optimizing preventive and therapeutic strategies for obesity-related cardiovascular disease.

Meanwhile, a study by the American College of Cardiology (ACC) reported that the risk of cardiovascular diseases such as hypertension and coronary heart disease in obese patients is 2–3 times higher than that in normal-weight people.[12] According to authoritative statistics, the incidence of both CVD and obesity has shown a continuous upward trend globally over the past few decades. In the United States, for example, the prevalence of obesity increased significantly from 30.5% in 1999 to 42.4% in 2017.[13] At the same time, the prevalence of CVD is also on the rise and is projected to increase from 11.3% to 15.0% between 2020 and 2025.[14] As the prevalence of almost all cardiovascular diseases and obesity is increasing, there is a growing interest in obesity control. In this context, breakthroughs in the efficacy of pharmacological treatments and weight-loss surgeries continue to be made, especially the development of emerging drugs such as glucagon-like peptide-1 (GLP-1) receptor agonists (tizapeptide, Semaglutide),[15] which have brought about great advances in the treatment of obesity. GLP-1 receptor agonists have challenged traditional views on obesity by regulating appetite and glucolipid metabolism, and have been shown to have significant effects in weight loss and cardiovascular risk reduction. Studies have shown that Semaglutide significantly improves metabolic markers and reduces cardiovascular events and mortality in obese patients.[16] This finding provides a new direction for the treatment of obesity and its associated cardiovascular diseases and also emphasizes the importance of early intervention.

Given that obesity is a preventable and reversible chronic disease, early intervention in obesity is the key to reducing morbidity and mortality. Therefore, in order to better prevent and intervene in the rise of obesity and to manage its spread, it is an urgent issue to understand the basic situation of the existing research worldwide at this stage, and to explore the contributions of different countries, institutions and authors in this field, as well as the foreseeable future trends in this field.

Citespace, and VOSviewer software are tools for creating visual bibliometric knowledge graphs based on web data, which are mainly used to quantitatively analyze the progress and dynamic changes in a particular research field, and can be used for co-occurrence analysis of information such as keywords, subject terms, authors, journals, countries, institutions, etc. They also provide text mining functionality.[17] Several current studies have noted that the use of bibliometrics in medicine is in a positive trend,[18,19] mainly because of its simplicity, speed, comprehensiveness, accuracy, and other advantages.

Therefore, the aim of this study is to perform a bibliometric analysis of publications on cardiovascular risk in obesity over the past 10 years (2014–2024) to determine the current state of research and to provide an outlook on research hotspots and future research trends.

Materials and Methods

Data Collection and Search Strategy

We conducted a literature search on September 15, 2024, for bibliometric studies related to cardiovascular risk in obesity in Web of Science (WOS), a comprehensive scientific literature database.[20] The literature search strategy was as follows:

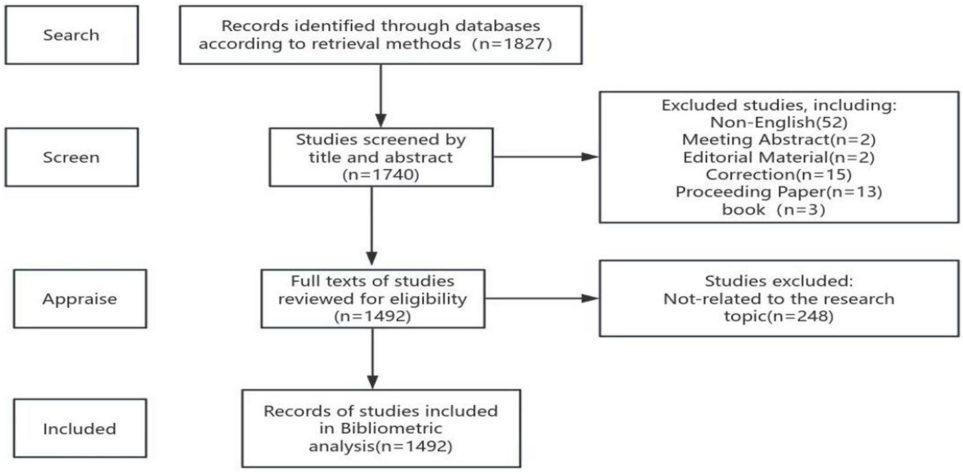

Figure 1 Literature search flow diagram.

TS=((“cardiovascular disease” OR “cardiovascular risk”) AND (“obesity” OR “adiposity”) AND (“adult”)) and excluded literature related to study populations of non-adults, and the type of literature study was restricted to review article/article, the language of the literature was set to “English”, the search time was set to “January 1, 2014, to September 1, 2024”. And the raw data, including complete records, cited references, and the original data, were downloaded in text format; and the flow chart of the literature search is shown in Figure 1.

Data Analysis

This study utilized the bibliometrics online analysis platform (https://bibliometric.com/) to conduct an analysis of the number of writings and publications in different countries/regions.

Citespace (version 6.3.R1), an information visualization literature analysis tool, was parameterized as follows: the methodology employed was the log-likelihood ratio algorithm (LLR), the time slices were set from January 2014 to September 2024 (each slice representing one year), and co-occurrence, clustering, and bursting analyses were performed.

VOSviewer (version 1.6.20) is a bibliometric analysis software[21] that extracts key information from a large number of publications and is commonly used to construct co-occurrence and co-citation networks, as well as to analyze research trends and hotspots. In this study, the software was primarily utilized for the following analyses: countries, institutions, publications and co-cited publications, authors and co-cited authors, highly cited papers, and keyword co-occurrence analysis. In the graphs produced by this software, a node represents an item, such as a country, a publication, an author, and so on, and the thicker the line between the nodes, the stronger the connection between the items, and the color and size of the nodes represents the number and category.[22]

Publications were quantitatively analyzed using Microsoft Office Excel 2019, where various details of the publications were extracted and analyzed including countries, authors, institutions, journals, year of publication, impact factor, etc. The partitioning and impact factor of journals were sourced from Journal Citation Report 2023.[23]

Data Extraction

Literature information was obtained independently by two researchers in accordance with the search strategy, and the divergent parts were discussed until a consensus was reached. The data were obtained from the WOS database, and the literature information was extracted and analyzed using Excel, VOSviewer and other relevant software.

Results

Global Overview and Quantitative Analysis of Publication

The search was conducted according to the search strategy, and 1492 articles (including 1278 articles and 214 review articles) were screened from the WOS database from January 1, 2014, to September 1, 2024 (Figure 1), with a total of

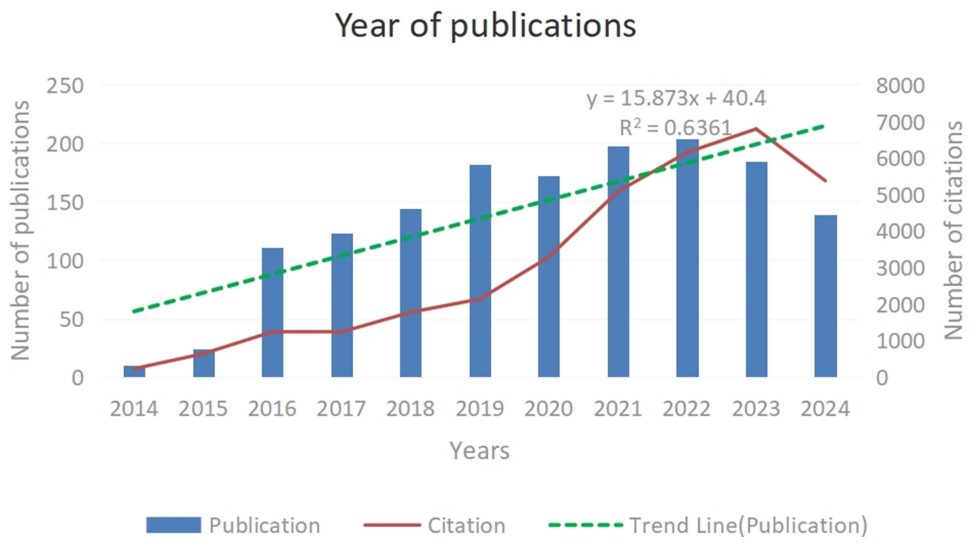

Figure 2 The number of publications and total citations.

33,960 citations, and an average of 22.8 citations per document. Overall, 9283 authors from 119 regions and countries published literature on obesity cardiovascular risk-related topics in 684 journals worldwide.

According to the publication trend line, the number of publications has shown an upward trend over the past decade. Although the data for 2024 are incomplete, it is expected that the number of publications will continue to increase rapidly in that year, indicating that more and more scholars are focusing on this area of research, and the related research process is advancing (Figure 2).

Analysis of Countries/Regions and Institutions

These publications came from 119 countries/areas and 2996 institutions.

Table 1 lists the top 10 countries/institutions in terms of the number of publications, and the country with the highest number of publications was the United States (n=420, 28.2%), followed by China (n=181, 12.2%), and the United Kingdom (n=125, 8.4%), accounting for nearly half of the total number of publications, with the United States had the highest number of citations (n=12,533). Noteworthy, as shown in Figure 3, after 2021, the number of publications in the

Table 1 Top 10 Countries/Institutions About Cardiovascular Disease Risk Studies on Obesity

Rank	Country	Counts	TLS	Institutions	Counts	TLS
1	USA	420	279	Universidade de São Paulo	38	84
2	China	181	164	University of Tehran Medical Sciences	29	48
3	England	125	173	Johns Hopkins University	22	107
4	Brazil	108	83	Universidade Federal de Minas Gerais	22	50
5	Australia	87	65	Ministry of Health	21	61
6	Iran	87	65	Harvard Medical School	18	63
7	Spain	82	61	Harvard T.H. Chan School of Public Health	17	12
8	Italy	73	72	Shahid Beheshti University of Medical Sciences	17	42
9	South Korea	70	50	Universidade Federal do Rio Grande do Sul	16	49
10	Canada	64	35	University of Pennsylvania	16	55

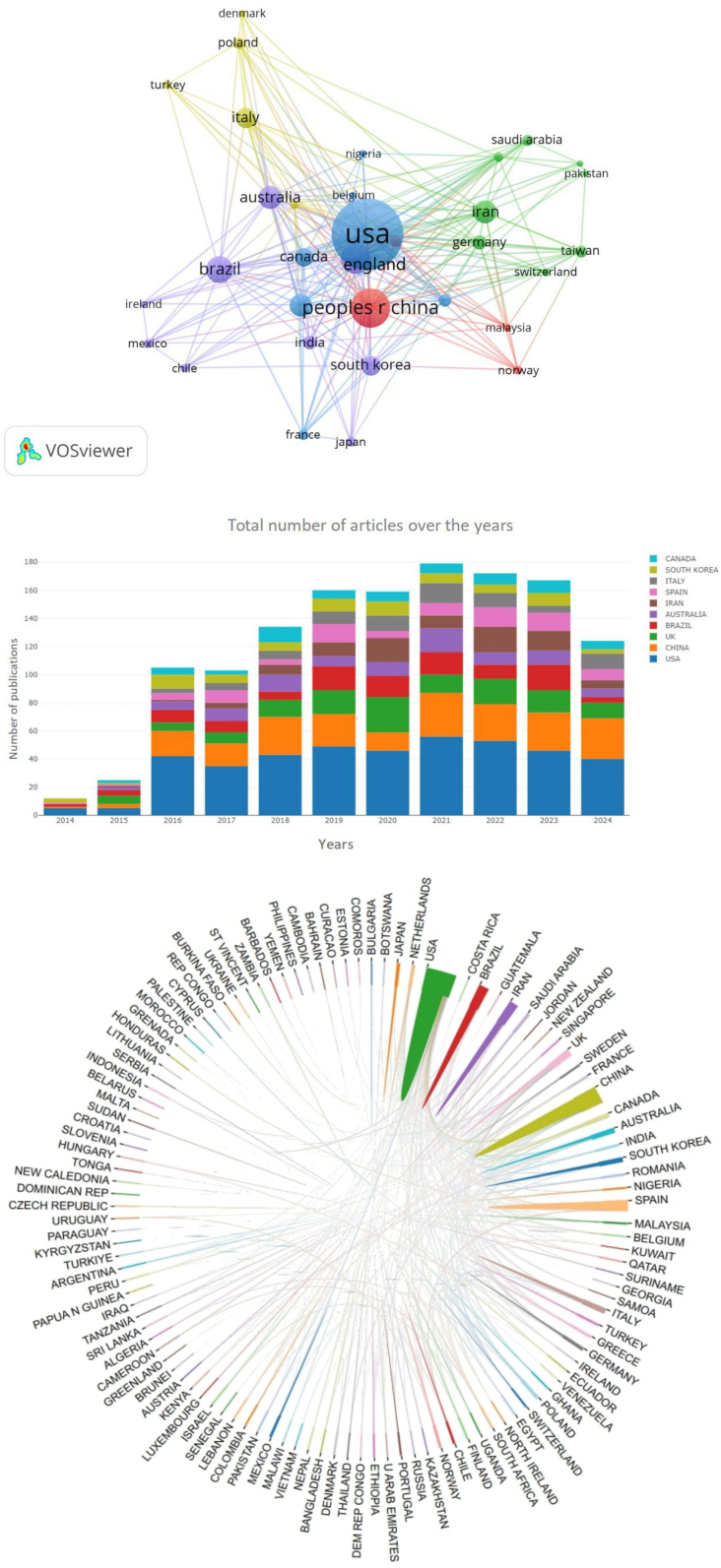

Figure 3 Publications and Collaboration Networks of the countries/regions.

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United States is decreasing but still at its highest level, and the number of publications in China is increasing, which may be due to the effects of the aging of the Chinese society's population as well as the increased risk of obesity and cardiovascular disease. (Figure 3) depict the network of collaboration between countries and regions, showing that the United States collaborates with several countries, especially China, the United Kingdom, and Iran. Total link strength (TLS) reflects the degree of closeness of the cooperative relationship between countries, which is indicated by the width of the line connecting the nodes, and is shown in Table 1, which shows that the top three countries in terms of TLS are the United States, the United Kingdom, and China. The cooperation intensity among other countries beyond these three is relatively low, highlighting the importance of strengthening international partnerships between international academic research institutions to further advance research in the area of cardiovascular risk in obesity.

The publications came from 2996 different institutions worldwide (Figure 4). From the ranking of statistical results, the Universidade de São Paulo has published the most papers (n = 38), followed by University of Tehran Medical Sciences (n = 29), Johns Hopkins University (n = 22), and Universidade Federal de Minas Gerais (n = 22).

Analysis of Journals

In the statistical analysis of this study, a total of 684 journals around the world published articles on this topic, but research on cardiovascular disease in obesity was mainly concentrated in nutrition and cardiovascular disease journals, with less research results in comprehensive journals. Subsequently, We selected 35 journals with ≥ 7 articles published and constructed a journal network diagram (Figure 5), which shows active citation relationships among journals such as "Nutrients", "Plos One", and "BMC Public Health".

Table 2 lists the top 10 journals in terms of the number of published papers (n=283, 19.0%), in which the journal Nutrients published the most papers (n=52, IF=4.8), followed by Plos One (n=45, IF=2.9). Among the top 10 journals in terms of the number of publications, three journals have more than 1000 citations, indicating that these journals have received widespread attention and recognition in the academic community and that they have performed well in terms of the quality of their papers, the popularity of their research fields, and the activeness of their scholarly exchanges. Among the top 10 journals in terms of the number of publications, the average impact factor is about IF=3.3. The journal with the

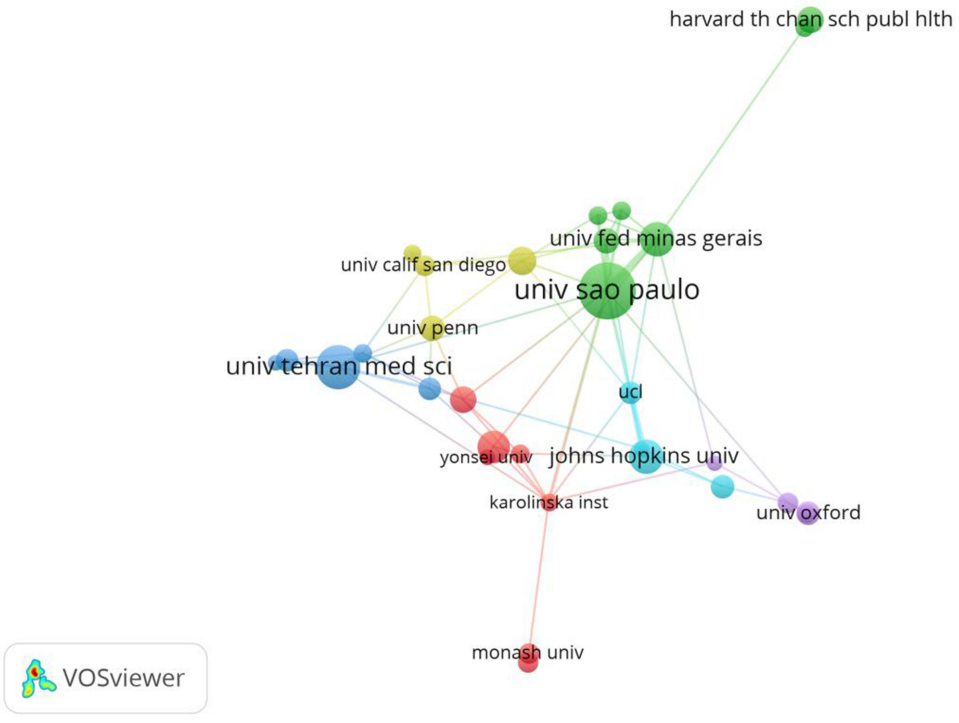

Figure 4 Collaboration network analysis of institutions.

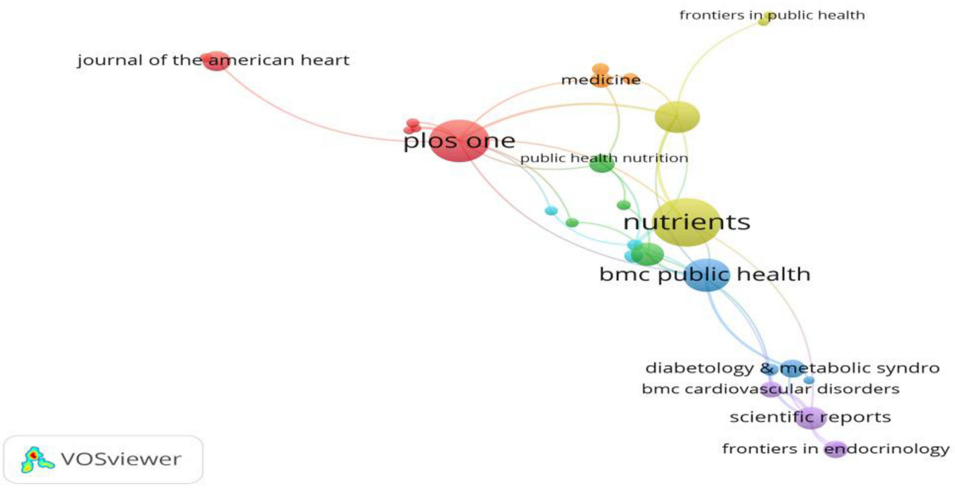

Figure 5 Collaboration network analysis of journals.

highest impact factor is the Journal of the American Heart Association (IF=5.0), which is a high-quality academic journal from the United States focusing on the cardiovascular field covering cardiovascular biology, disease prevention, clinical research, and therapeutic innovation. Due to the high quality of papers published in this journal and the wide range of research it covers, it is expected that research in this field will continue to be of significant importance in the coming years.

Analysis of Authors

From the statistics of this study, a total of 9283 authors worldwide were involved in studies related to cardiovascular risk in obesity. Among the top 10 authors in terms of the number of publications, each author published an average of more than or equal to 5 articles (Table 3). Among them, Paulo A. Lotufo published the highest number of papers (n=14), with 187 citations and an average of 13 citations per publication. The author with the highest number of citations among the top 10 authors was Asmaa S. Abdelhamid, who published five papers with a total of 546 citations, indicating that her papers were of good quality and highly recognized by her peers. We constructed a collaborative network based on the 60

Table 2 Top 10 Journals About Cardiovascular Disease Risk Studies on Obesity

Rank	Journal	Counts	Citations	IF (2023)	JCR Quartile
1	Nutrients	52	1127	4.8	Q1
2	Plos One	45	970	2.9	Q1
3	BMC Public Health	34	1223	3.5	Q1
4	International Journal of Environmental Research And Public Health	32	1253	4.6	Q2
5	BMJ Open	23	214	2.4	Q1
6	Scientific Reports	22	628	3.8	Q1
7	Cureus Journal of Medical Science	21	80	1.0	Q3
8	Journal of the American Heart Association	19	313	5.0	Q1
9	Metabolic Syndrome And Related Disorders	18	81	1.3	Q4
10	Diabetology & Metabolic Syndrome	17	195	3.4	Q2

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Table 3 Top 10 Authors About Cardiovascular Disease Risk Studies on Obesity

Rank	Author	Counts	Citations	TLS	Country
1	Paulo A. Lotufo	14	187	25	Brazil
2	Isabela M. Bensenor	13	178	25	Brazil
3	Sandhi M. Barreto	11	100	11	Brazil
4	Schmidt Maria Ines	7	65	8	Brazil
5	Fereidoun Azizi	6	142	0	Iran
6	Khurram Nasir	6	45	1	USA
7	Itamar S. Santos	6	54	14	Brazil
8	Asmaa S. Abdelhamid	5	546	60	England
9	Marcio S. Bittencourt	5	25	13	USA
10	Michael J. Blaha	5	39	3	USA

authors who published more than or equal to four papers (Figure 6). According to the mapping, in the field of obesity and cardiovascular risk research, there is a close collaboration between authors such as Paulo A. Lotufo and Peter P. Toth, but we also found that the scale of collaboration among authors is relatively small, and that there is a need to strengthen the overall connection and collaboration among researchers in this field.

Research Hotspots

Analysis of Co-Cited Journals

Journal co-citation analysis is an effective method to evaluate the quality and impact of academic journals. As shown in Table 4, among the top 10 co-cited journals, all of them are Q1 journals, and the most cited journal is Circulation, with 2050 citations. It is noteworthy that seven journals have been cited more than 1000 times, including some high-quality academic journals, such as The Lancet (IF=98.4) and New England Journal Of Medicine (IF=96.2), which indicate that the reliability and level of the published research papers are high. Journals with a minimum co-citation equal to 150 were filtered to present the co-citation network graph (Figure 7). As shown in the figure, there is a strong citation relationship between journals such as Circulation, Diabetes Care, and Plos One.

Analysis of Co-Cited Authors

The co-citation authors analysis is performed to reveal the academic associations and collaboration patterns among authors. By filtering the authors with a minimum co-citation equal to forty, we mapped the authors' co-citation network, which is shown in Figure 8. As illustrated in the figure, there is also an active collaboration between different co-citing authors. Among the top ten co-cited authors, six authors had more than 100 co-citations (Table 5). Grundy SM ranked first with 285 citations, followed by WHO (n=233), and Alberti KGMM (n=228). The total number of citations for the top ten co-cited authors exceeded 1500 citations, illustrating their high degree of academic influence as well as their significant contributions in the field of cardiovascular disease risk in obesity.

Analysis of Highly Co-Cited References

In the past decade, there have been 62,224 cited references about cardiovascular disease in obesity research worldwide. Table 6 lists the top 10 ranked literature in terms of the number of co-citations, all of the top 10 co-cited references have been cited more than 40 times, with two of them exceeding 100 citations. In this study, a co-citation network diagram was constructed by selecting the literature with at least thirty co-citations, and the co-citation network diagram is shown in Figure 9. From this diagram, we can conclude that the co-citation relationships are mainly divided into three main

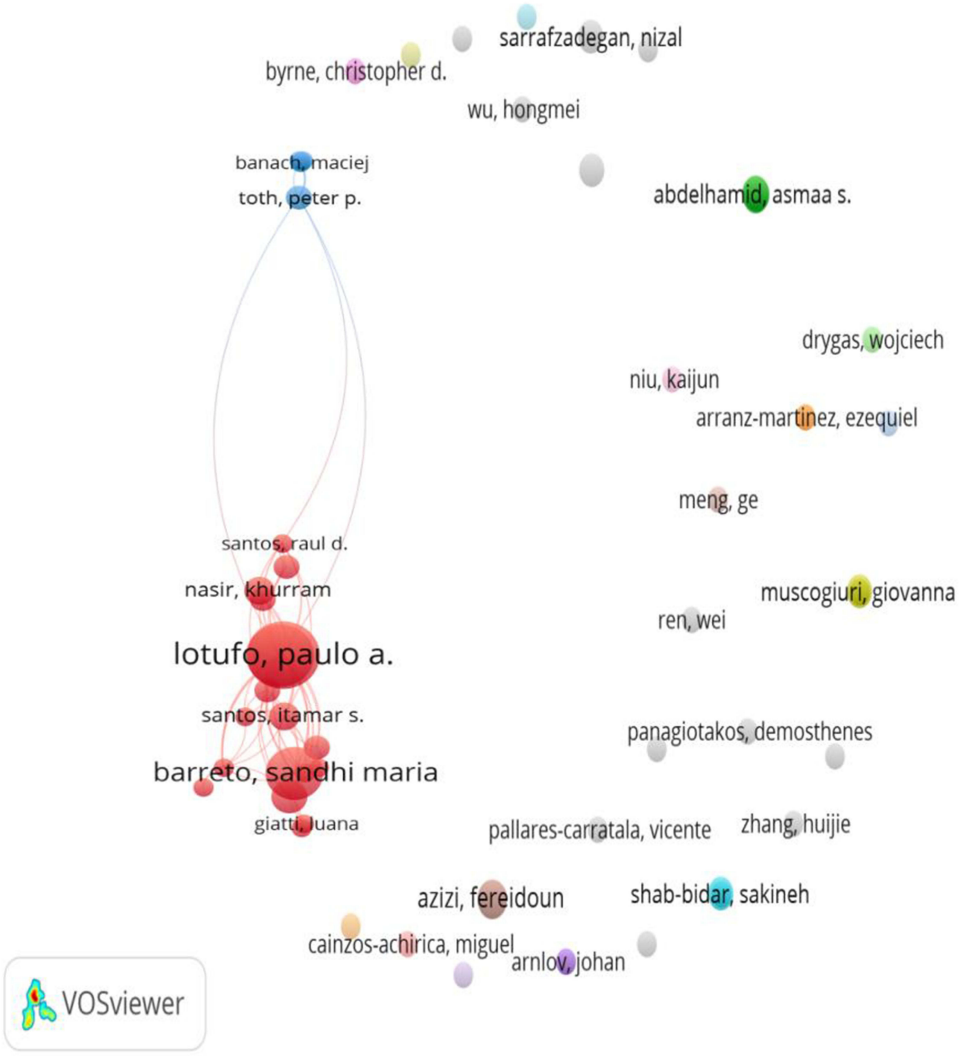

Figure 6 Collaboration network analysis of authors.

categories: (1) the relationship between obesity, overweight and cardiometabolic health, as well as the corresponding epidemiological studies; (2) the prediction of metrics such as cholesterol levels, high blood pressure, waist circumference ratio, and BMI with cardiometabolic diseases; (3) the prediction of high cholesterol, metabolic syndrome and their relationship with cardiovascular disease risk.

Table 4 Top 10 Co-Cited Journals About Cardiovascular Disease Risk Studies on Obesity

Rank	Journals	Citations	TLS	IF (2023)	JCR Quartile
1	Circulation	2050	71862	35.5	Q1
2	Lancet	1661	67013	98.4	Q1
3	Diabetes Care	1547	51222	14.8	Q1
4	Plos One	1496	51810	2.9	Q1
5	Jama-journal Of The American Medical Association	1309	49840	63.1	Q1
6	New England Journal of Medicine	1075	49764	96.2	Q1

(*Continued*)

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Table 4 (Continued).

Rank	Journals	Citations	TLS	IF (2023)	JCR Quartile
7	American Journal Of Clinical Nutrition	1066	47454	6.5	Q1
8	Journal of the American College of Cardiology	962	33613	21.7	Q1
9	Journal of Clinical Endocrinology & Metabolism	910	33812	5.0	Q1
10	International Journal Of Obesity	822	29887	4.2	Q1

Analysis of Keywords Co-Occurrence and Cluster

High-frequency and high-centrality keywords often reflect the research hotspots in a particular field. This study extracts a total of 5314 keywords, and Table 7 reports the top 20 high-frequency keywords. By conducting keywords co-occurrence analysis, we filtered keywords with the number of occurrences greater than or equal to forty, and this analysis revealed fifty-eight keywords co-occurrence networks, as shown in Figure 10. Among these keywords, "risk factors", "BMI", "insulin resistance" appeared more than 200 times, indicating the main research dynamics of cardiovascular risk in obesity. The high-frequency keywords of related diseases mainly include "obesity", "cardiovascular diseases", "metabolic syndrome", etc. The high-frequency keywords of research directions are "epidemic", "risk factors", "association", "mortality", etc. The main aspects of the mechanisms involved are "insulin resistance", "oxidative stress", etc. Among them, "risk", "hypertension", "obesity" and "cardiovascular diseases" have good centrality.

It illustrates the clustering analysis of the above keywords in Figure 11, where different clusters are indicated by different colors, and the contour value of each cluster is above 0.7, indicating better clustering quality. To demonstrate the time trend and the evolution of the development of the themes over time, a timeline graph was constructed (Figure 12). Ten clusters and cluster label keywords were further generated by the log-likelihood ratio: #0 "blood pressure", #1 "metabolic syndrome", #2 "risk", #3 "body composition", #4 "waist circumference", #5 "obesity paradox", #6 "United States", #7 "weight loss", #8 "cardiovascular diseases", and #9 "meta-analysis" (Table 8).

Analysis of Keywords with the Strongest Citation Bursts

The analysis of burst keywords in CiteSpace is used to identify and display keywords in scientific literature that have experienced a significant increase in citation frequency over a short period of time, in order to reveal research hotspots,

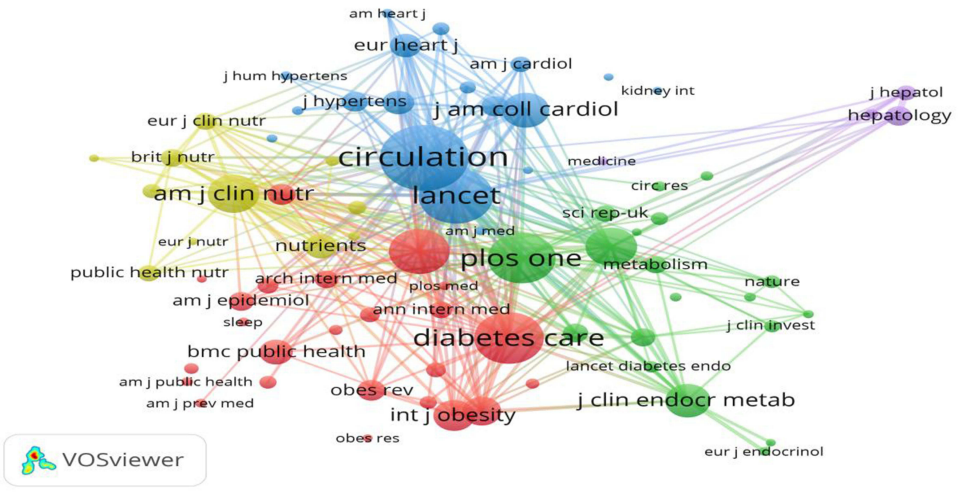

Figure 7 Collaboration network analysis of co-cited journal.

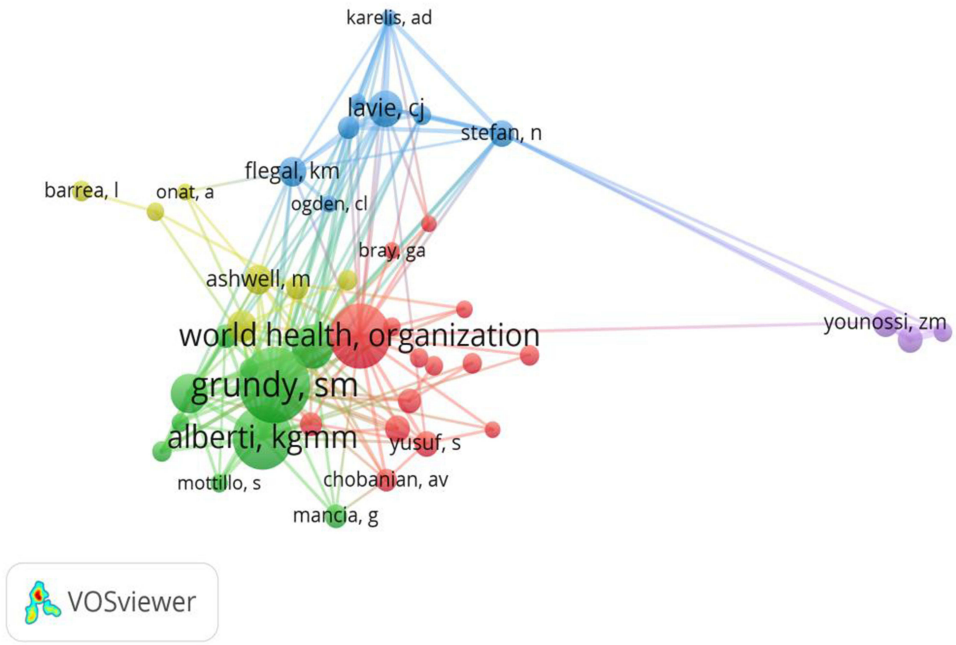

Figure 8 Collaboration network analysis of co-cited author.

predict development trends, and discover emerging areas. Over the past decade, a total of 25 keywords have experienced significant bursts in this research area. The results of the burst detection are shown in Figure 13, where the blue line represents the time intervals and the red line indicates the time period during which the keyword bursts occurred. The outcomes and impacts of major diseases were the focus in the earlier period. Whereas after 2020, the research primarily centered on the intrinsic mechanisms and influencing factors between health and physiological indicators and diseases. And in recent years, keywords such as "cholesterol", "oxidative stress", "nonalcoholic fatty liver disease (NAFLD)", and "to height ratio", have become prominent. This suggests that research on these topics is currently gaining more attention and shows potential for growth.

Table 5 Top 10 Co-Cited Authors About Cardiovascular Disease Risk Studies on Obesity

Rank	Author	Citations	TLS
1	Grundy SM	285	955
2	WHO	233	709
3	Alberti KGMM	228	881
4	Cleeman JI	143	598
5	Ford ES	120	474
6	Lavie CJ	109	522
7	Ridker PM	92	231
8	Flegal KM	85	336
9	Ashwell M	84	333
10	Younossi ZM	78	451

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Table 6 Top 10 Co-Cited Reference About Cardiovascular Disease Risk Studies on Obesity

Rank	Co-Cited Reference	Co-Cited Reference	Counts	LTS
1	Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) Blood Cholesterol in Adults (Adult Treatment Panel III)	cleeman ji, 2001, jama-j am med assoc, v285, p2486, doi:10.1001/jama.285.19.2486	141	739
2	Harmonizing the Metabolic Syndrome A Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention. National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity	alberti kgmm, 2009, circulation, v120, p1640, doi:10.1161/circulationaha.109.192644	103	484
3	Diagnosis and Management of the Metabolic Syndrome An American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement	grundy sm, 2005, circulation, v112, p2735, doi:10.1161/circulationaha.105.169404	71	306
4	National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High BloodCholesterol in Adults (Adult Treatment) Expert Panel on Detection, Evaluation, and Treatment of High BloodCholesterol in Adults (Adult Treatment)	grundy sm, 2002, circulation, v106, p3143, doi:10.1161/circ.106.25.3143	68	284
5	Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure	chobanian av, 2003, hypertension, v42, p1206, doi:10.1161/01.hyp.0000107251.49515.c2	54	193
6	Homeostasis model assessment: insulin resistance and fl-cell function from fasting plasma glucose and insulin concentrations in man	matthews dr, 1985, diabetologia, v28, p412, doi:10.1007/bf00280883	54	239
7	The Metabolic Syndrome and Cardiovascular Risk A Systematic Review and Meta-Analysis	mottillo s, 2010, j am coll cardiol, v56, p1113, doi:10.1016/j.jacc.2010.05.034	47	257
8	The metabolic syndrome-a new worldwide definition	alberti kgmm, 2005, lancet, v366, p1059, doi:10.1016/s0140-6736(05)67402-8	45	253
9	Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis	ashwell m, 2012, obes rev, v13, p275, doi: 10.1111/j.1467-789x.2011.00952.x	44	202
10	Special report Metabolic syndrome K. G. M. M. Alberti et al. Metabolic syndrome-a new world-wide definition. A Consensus Statement from the International Diabetes Federation A Consensus Statement from the International Diabetes Federation	alberti kgmm, 2006, diabetic med, v23, p469, doi:10.1111/j.1464-5491.2006.01858.x	43	218

Discussion

General Information

As the global aging population intensifies, the risk of cardiovascular disease among elderly patients with obesity is also increasing dramatically.[24,25] Bibliometric studies provide an important foundation for understanding the research trends in obesity and cardiovascular disease. Although previous studies have not yet conducted bibliometric analyses specifically on cardiovascular risk in obese patients, many scholars have conducted extensive research in the separate fields of obesity or cardiovascular disease. For example, studies by Su et al[26] and Pezzino[27] have primarily focused on gut microbiota-related mechanisms and innovative therapies for obesity, whereas studies by Mao et al[28] and Tang et al[29] have focused on the pathogenesis, diagnostic and therapeutic techniques, and preventive strategies of cardiovascular disease.

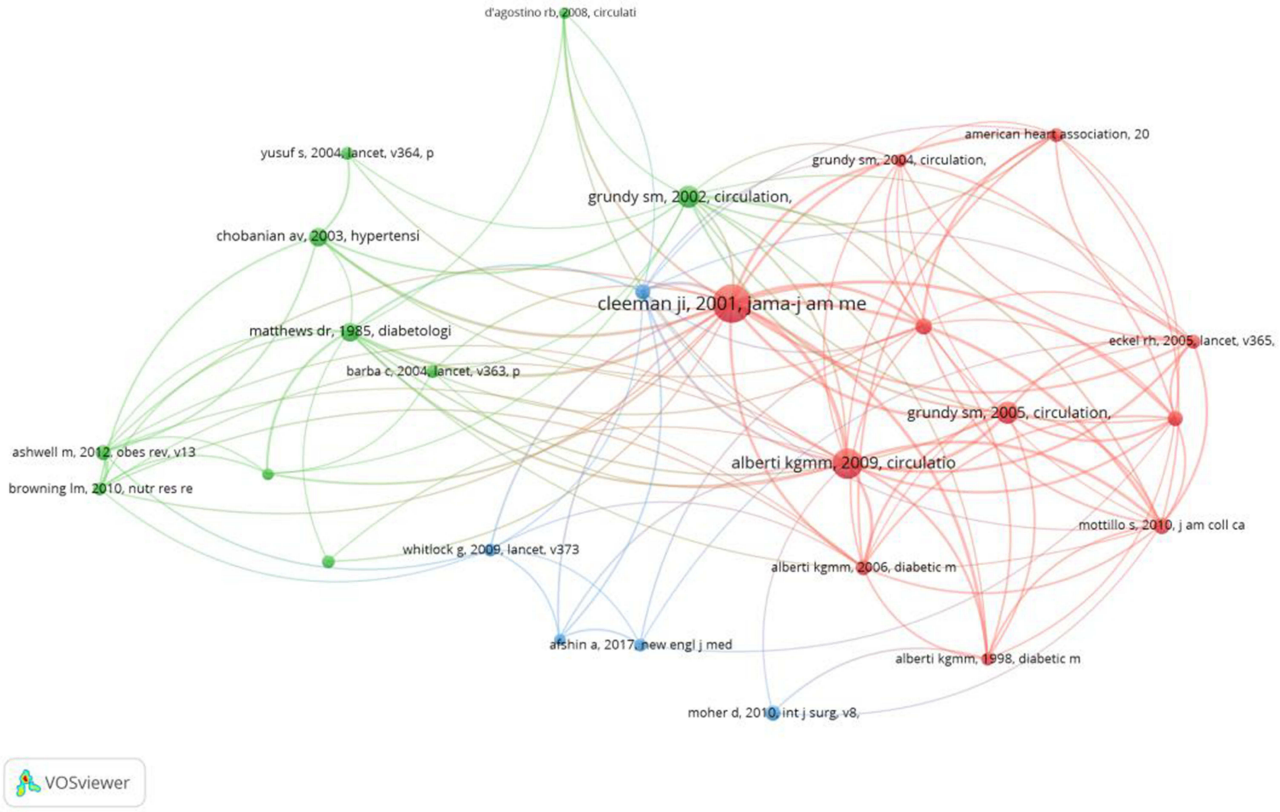

Figure 9 Collaboration network analysis of co-cited References.

In this study, we analyzed the articles on such diseases published in the WOS database in the last decade. Through the in-depth analysis of countries, institutions, journals, authors, and keywords, we have explored the research hotspots and trends in this field by using software such as Vosviewer and Citespace, in order to identify the connections among them and provide a basis for subsequent development of prevention and treatment strategies for the disease.

Table 7 Top 20 high-Frequency Keywords About Cardiovascular Disease Risk Studies on Obesity

Rank	Keywords	Occurrences	Occurrences Centrality	Rank	Keywords	Occurrences	Occurrences Centrality
1	Cardiovascular disease	589	0.27	11	Cardiovascular risk	177	0.01
2	Obesity	452	0.22	12	Health	157	0.1
3	Metabolic syndrome	409	0.04	13	Physical activity	155	0.06
4	Prevalence	305	0.01	14	Disease	154	0.01
5	Risk factors	268	0.16	15	Cardiovascular risk factors	143	0.01
6	Risk	268	0.36	16	Blood pressure	131	0.01
7	Body mass index	239	0.03	17	Population	123	0.05
8	Mortality	221	0.24	18	Hypertension	121	0.39
9	Association	208	0.06	19	Waist circumference	117	0.01
10	Insulin resistance	207	0.01	20	Adults	117	0.13

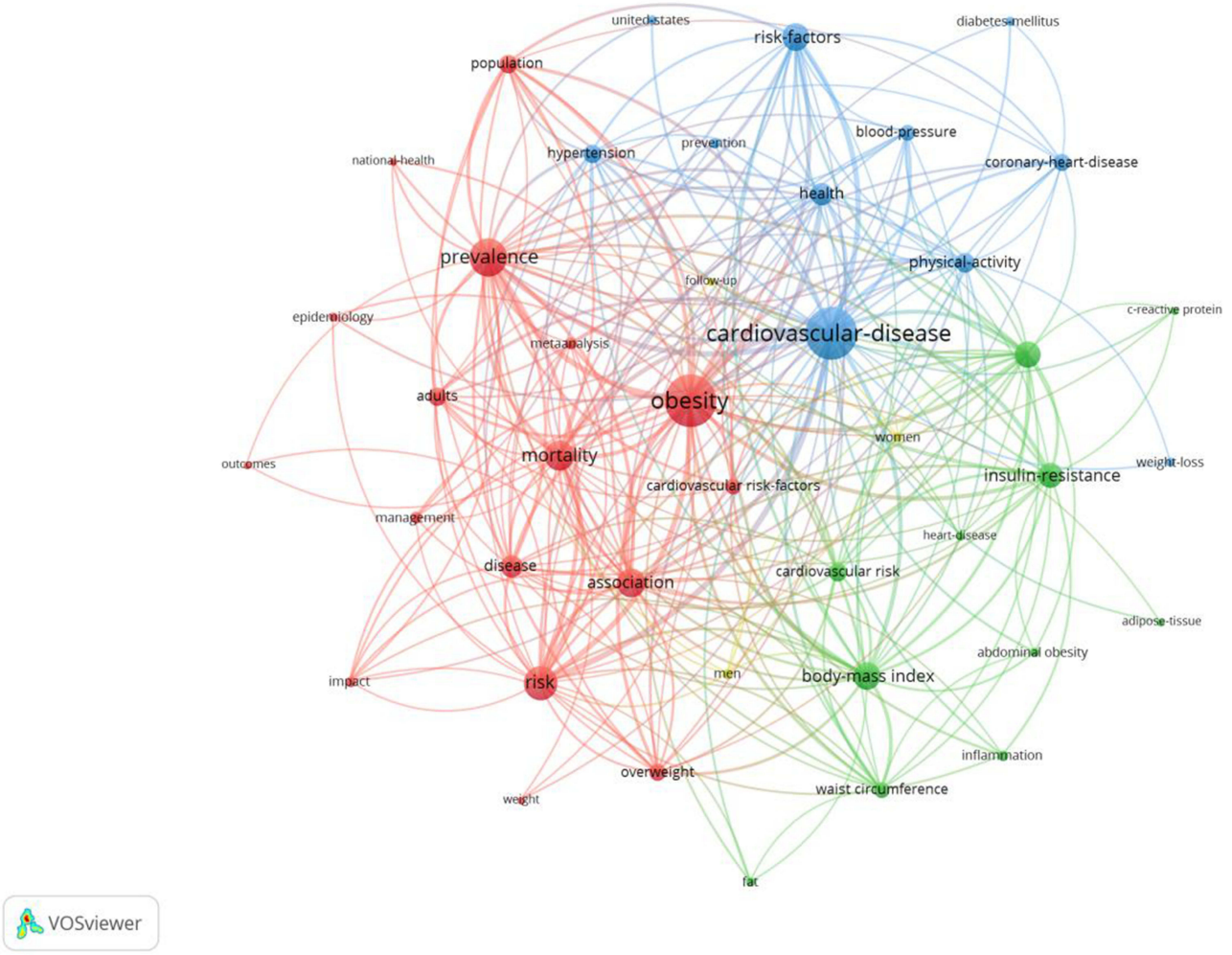

Figure 10 Collaboration network analysis of keyword co-occurrence.

Over the past decade, the number of studies on cardiovascular risk in obesity patients has grown rapidly, with a total of 1492 articles and 33,960 citations. This rapid growth indicates that research in this area is receiving more and more attention from scholars. This is likely due to the fact that the public pays attention to their own health, and the concept of scientific aging is deeply rooted in people's minds. More and more scholars are increasingly recognizing the importance of understanding the relationship between chronic diseases such as obesity and cardiovascular risks, and their impact on the quality of life and health risks of the elderly. Consequently, research in this field has shown a rapid growth trend in the past decade.

Among the 119 countries/regions conducting such research, the United States is the leading country with the highest number of publications. In addition, after 2021, the number of publications in the United States is decreasing but still at the highest in both variety and number compared with other countries, and the number of publications in China is growing rapidly, which may be due to the impact of the severe demographic aging of the Chinese society as well as the increased risk of obesity and cardiovascular disease. In terms of national collaborations, the United States also demonstrated the largest production of publications and a strong position in terms of international cooperation. From the research statistics, the intensity of collaborations is low among countries other than the United States, the United Kingdom, and China. Therefore, strengthening international cooperation among countries and institutions is necessary to further advance global research on cardiovascular risks associated with obesity.

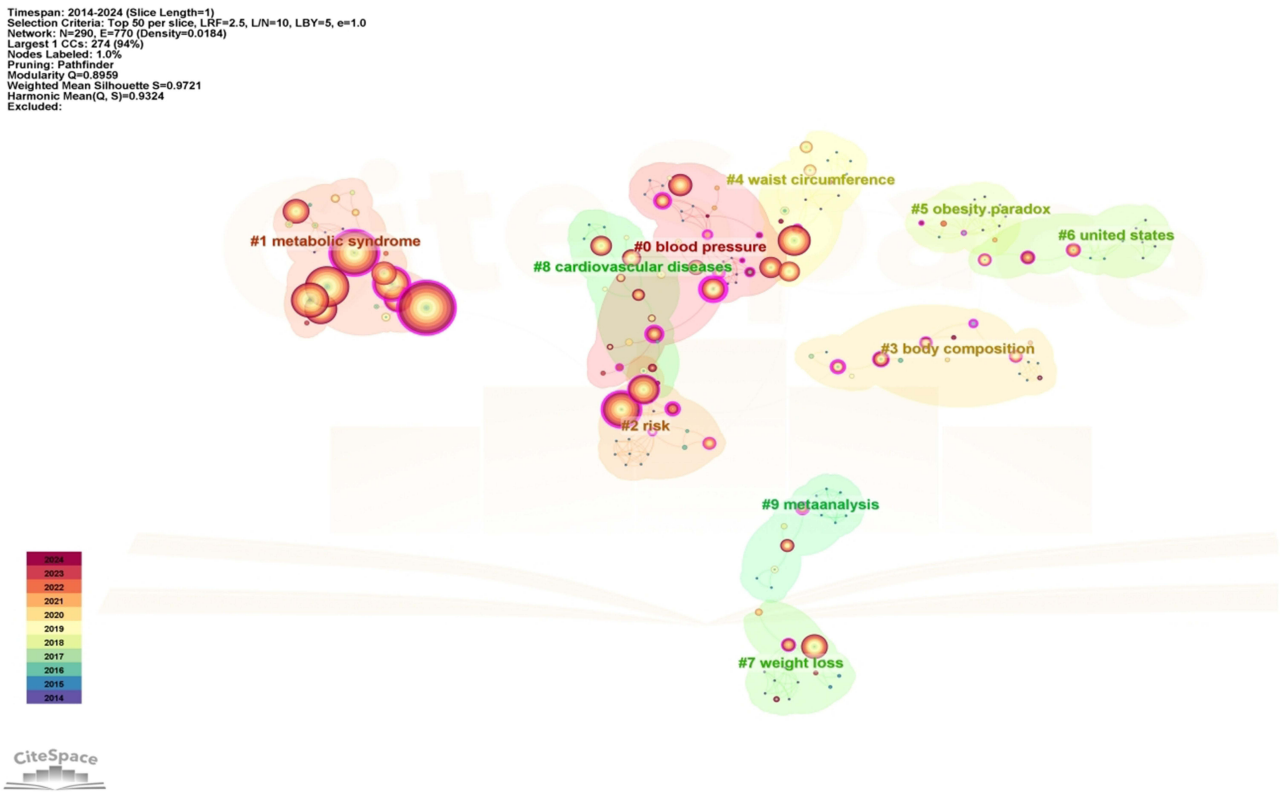

Figure 11 Visualization of Keyword clustering.

The top ten issuing institutions accounted for 14.5% of the total number of publications, indicating that they have made a significant contribution to the academic achievements in the field. Universidade de São Paulo, the institution with the most publications, collaborates closely with Universidade Federal de Minas Gerais, which ranks third in terms of publications. Both of them have shown excellent research investments and publication output in this field. Although the University of Tehran Medical Sciences also has a high number of publications, its collaboration with other institutions lags behind in terms of scope and intensity, which may not be conducive to the long-term development of research. Therefore, it is recommended that academic institutions worldwide strengthen the cooperation, maintain close contact, and make collective efforts to advance medical research in the field of cardiovascular risk in obesity.

In terms of the journals publishing the results, globally, a total of 684 journals have published articles on the relevant topics, with the top 10 accounting for 19.0% of all publications. The topics related to this study were predominantly featured in nutrition and cardiovascular disease journals. Among these, Nutrients led in terms of publication count (IF=4.8), while the Journal of the American Heart Association boasted the highest impact factor (IF=5.0). This indicates that some high-quality journals provided strong support and assistance for the study.

Authorship analysis is conducted to reveal the authors' research contributions, collaborative networks, and academic influence, providing references for researchers in terms of collaboration and research directions. In terms of the authors of publications, Paulo A. Lotufo and Isabela M. Bensenor are the authors with the largest number of publications.[30,31] Paulo A. Lotufo, with a solid background in medicine and public health, has dedicated his career to cardiovascular disease research, his research covers a wide range of aspects such as the epidemiology of cardiovascular diseases, risk factors, preventive strategies, and clinical trials,[32,33] providing a scientific basis for the development of effective prevention and treatment strategies.

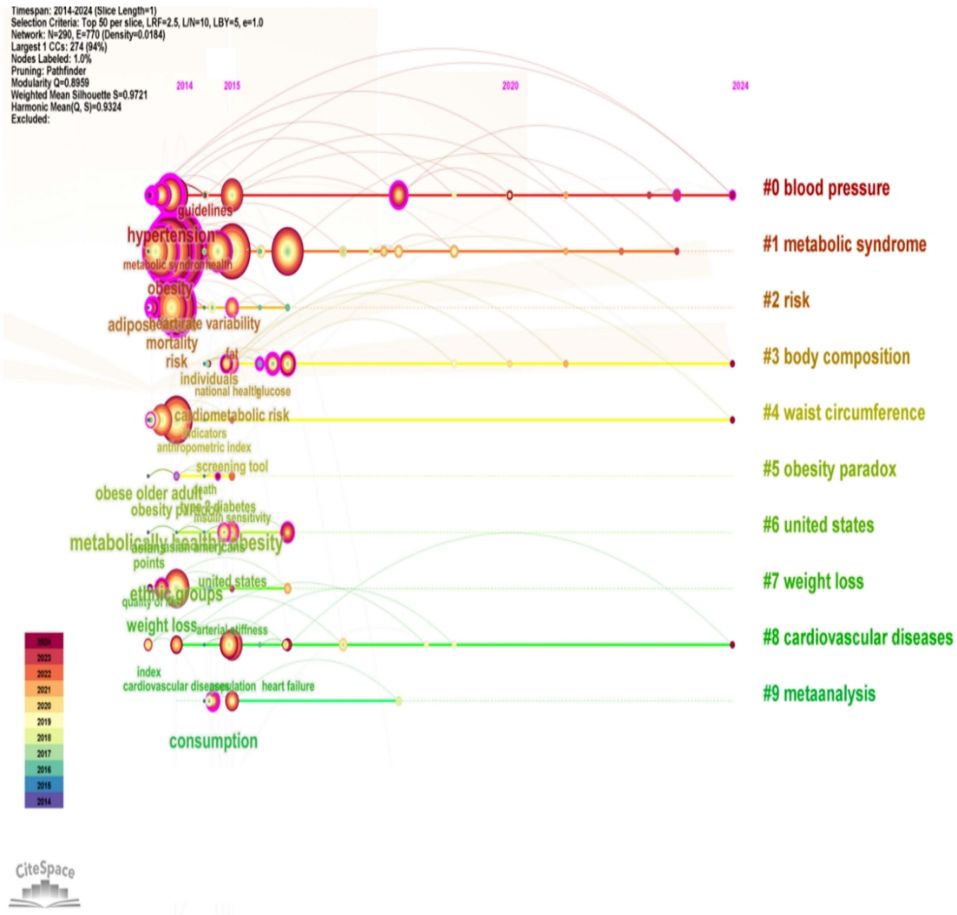

Figure 12 Timeline of keywords.

Research Hotspots

By analyzing the co-citation frequency and co-citation network of journals, we can objectively evaluate the academic level and influence of journals. Based on the co-cited journal analysis, the top 10 most cited papers listed in this study are all from Q1 journals. Among them, the most cited journal is Circulation, which is a medical journal published by the

Table 8 Keywords Cluster Analysis About Cardiovascular Disease Risk Studies on Obesity

Cluster-ID	Label	Silhouette	Size	Coverage
#0	Blood pressure	0.984	31	Blood pressure; diabetes mellitus; abdominal obesity; hypertension; risk factor
#1	Metabolic syndrome	1	26	Metabolic syndrome; physical activity; insulin resistance; risk factors; health
#2	Risk	0.886	18	Risk; mortality; ckd; marker; expression
#3	Body composition	0.933	17	Body composition; cardiometabolic risk; phase angle; uric acid; sarcopenia
#4	Waist circumference	0.993	16	Waist circumference; body mass index; waist-to-height ratio; men; hip ratio

(*Continued*)

Table 8 (Continued).

Cluster-ID	Label	Silhouette	Size	Coverage
#5	Obesity paradox	0.998	14	Obesity paradox; drug utilization; secretion; homeostasis model assessment; orthopedic surgery
#6	United States	1	14	United States; type 2 diabetes mellitus; t2dm; catestatin; shingles
#7	Weight loss	1	14	Weight loss; plant-based diet; therapeutic use; mortality; cardiovascular disease
#8	Cardiovascular diseases	0.826	14	Cardiovascular diseases; cholesterol; blood; middle aged
#9	Meta-analysis	1	14	Meta-analysis; end-stage kidney disease; depressed individuals; major depressive disorder; persistence

American Heart Association with high academic status and influence in the field of cardiovascular medicine.[34] Additionally, other high-quality journals such as The New England Journal of Medicine and The Lancet have also provided academic support and platform resources for the study.

The co-cited authors analysis aims to uncover patterns of academic associations and collaboration among authors. Among the top ten co-cited authors, six authors have more than 100 citations, with Grundy SM ranking at the top. In his latest paper, he explored how multiple risk factors (such as biochemical markers, lifestyles, chronic diseases, etc) influence the occurrence and progression of atherosclerotic cardiovascular disease (ASCVD) and evaluated the accuracy and validity of these risk factors in predicting ASCVD risk, his research helps doctors more accurately identify and manage high-risk patients, thereby providing a foundation for developing more effective prevention and treatment strategies.[35]

Co-cited references refer to those that are cited together by multiple other publications and can therefore be regarded as the research foundation of a particular field.[36] In this study, we selected the top 10 most co-cited references, with the highest number of co-citations belonging to papers published by the NCEP expert panel.[37] These papers focus on summarizing the methods for identifying hyperlipidemia, outlining the criteria for its assessment, and presenting treatment options, with the aim of helping physicians and patients to better manage hyperlipidemia, thereby reducing or circumventing risk factors for cardiovascular diseases such as coronary heart disease. This indicates that current research not only focuses on the mechanism of disease occurrence, but also emphasizes early intervention and prevention awareness.[38,39]

Keyword analysis can help researchers quickly capture the distribution of hotspots in this research field.[40] Through keyword co-occurrence analysis, this study found high-frequency keywords such as cardiovascular disease, obesity, insulin resistance, risk factors, BMI, health, physical activity, etc. This reflects that research in this field not only has an in-depth discussion on issues such as the relationship between obesity and its physiological mechanisms and cardiovascular disease[41,42] but also indicates that researchers are beginning to pay more attention to managing and preventing the occurrence of obesity-related cardiovascular diseases through non-pharmacological interventions.[43] Researchers believe that regular physical activity, along with increased health awareness and improved daily lifestyle, is the best strategy for effective CVD prevention.[44]

Global Trends

Keyword Cluster Analysis and Trend Topic Analysis

Based on the keyword cluster analysis and trend topic analysis, a total of ten clusters were obtained, which can be classified into the following three sections based on the content and relevance of these clusters. We have then summarized the themes of each section:

Part I: Health Indicators and Diseases: This part mainly includes the four clusters of #0 blood pressure, #3 body composition, #4 waist circumference, and #8 cardiovascular diseases. This part of the vocabulary is mainly related to the

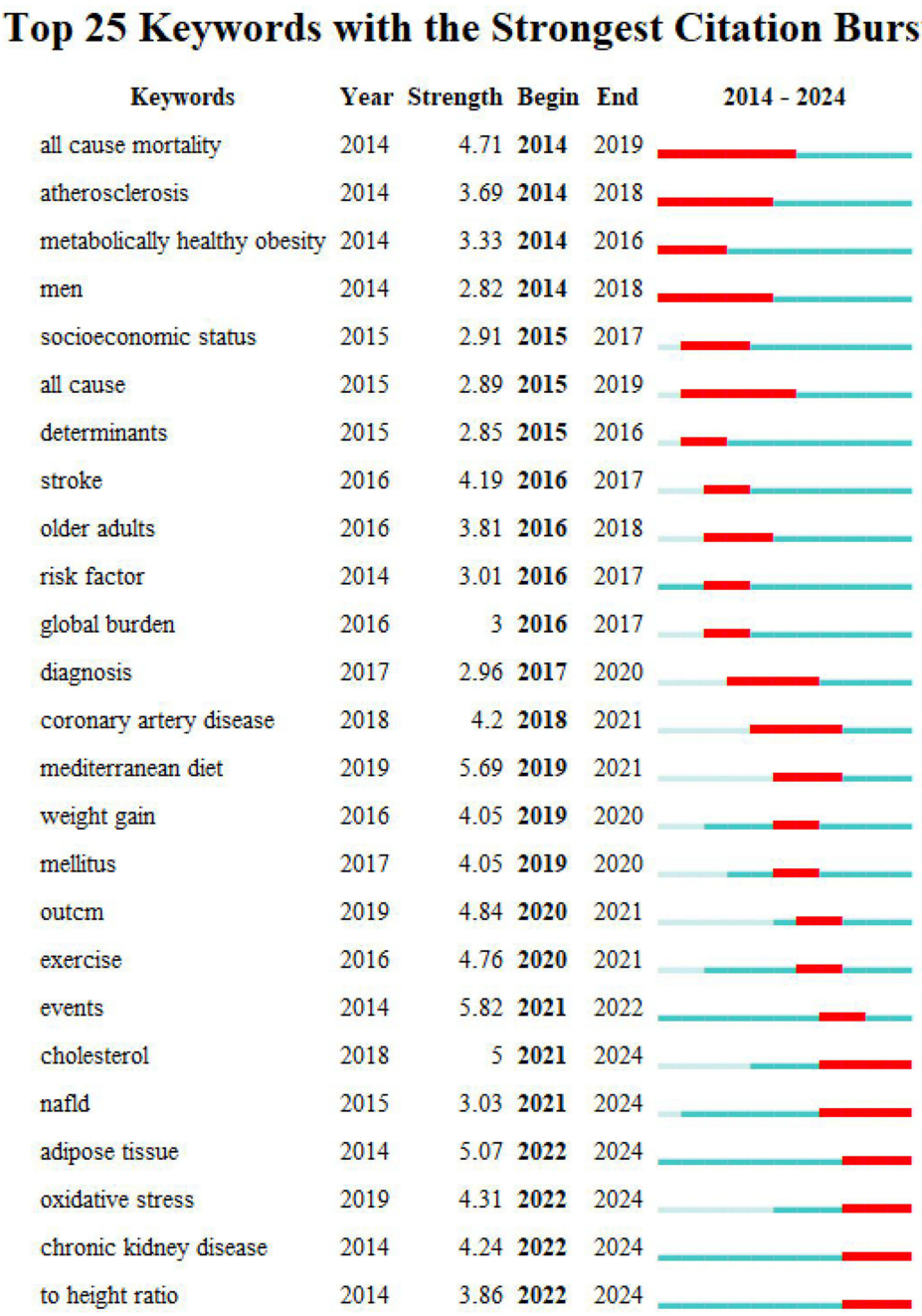

Figure 13 Visualization map of top 25 keywords with the strongest citation bursts.

human body's health indicators (such as blood pressure, body composition, waist circumference) and diseases associated with them (such as cardiovascular diseases). Some studies have shown that cardiovascular diseases are serious health issues closely related to indicators such as elevated BMI and increased waist circumference, which are commonly used to assess the health status of individuals and have an impact on the overall health of the population.[45,46]

Part II: Metabolism and Obesity: This part of the vocabulary focuses on the body's metabolic state and obesity issues: #1 metabolic syndrome, #5 obesity paradox, #7 weight loss. Metabolic syndrome is a condition characterized by multiple metabolic abnormalities, which is clinically characterized by a range of vascular risk factors, including insulin resistance, hypertension, abdominal obesity, and impaired glucose metabolism, all of which increase the risk of cardiovascular events.[47,48] Conversely, the literature on the obesity paradox highlights that, although obesity generally increases the risk of cardiovascular

disease, overweight and obese individuals with cardiovascular disease have a better prognosis than lean patients and also underscores the importance of weight management, weight loss, and physical activity in the prevention of cardiovascular disease.[49] It is noteworthy that in recent years, GLP-1 agonists have demonstrated unique advantages in improving the metabolic state of the human body and addressing obesity.[15] They not only regulate blood glucose, improve insulin resistance, and positively affect key abnormalities in metabolic syndrome (eg, hypertension, dyslipidemia), but are also effective in weight management, helping obese patients to achieve their weight loss goals, and thus alleviating obesity-associated cardiovascular disease risk to a certain extent. Several clinical studies have confirmed the effectiveness of GLP-1 agonists. For example, in a multicenter, double-blind, randomized, placebo-controlled clinical trial (the SELECT trial), a significantly lower incidence of cardiovascular events was found in patients treated with GLP-1 agonists (eg, Semaglutide) versus placebo patients (risk ratio: 0.80; 95% CI: 0.72–0.90),[50] suggesting that the use of GLP-1 agonists in such patients significantly reduces the risk of cardiovascular events. Another meta-analysis study of multiple randomized controlled trials also demonstrated a significant effect of GLP-1 agonists in helping obese individuals lose weight.[51] In summary, GLP-1 agonists bring new ideas and solutions to address the metabolic syndrome and the obesity paradox, and open up new avenues for the prevention and treatment of CVD.

Part III: Geography and Research Methods: The vocabulary in this part includes: #6 United States, #9 meta-analysis, which involve geographical location and research methods respectively. Due to its large population, economic development, and diverse lifestyles, the United States has become a major country with a high prevalence of cardiovascular disease in populations with obesity and a focus of related research.[52] Meta-analysis is a statistical method mainly used to synthesize the results of multiple independent studies in order to draw more reliable and comprehensive conclusions. In obesity and cardiovascular disease research, meta-analysis is often used to assess the effectiveness of different interventions, as well as to be able to compare issues such as the advantages and disadvantages between different treatments.[53]

The Strongest Keyword Bursts

Outburst keywords (also known as emergent words) are used to study issues such as research frontiers and hot trends within a specific field.[54]

Analyzing the keyword bursts, this study found that during the period 2014–2020, the main research focus was on issues such as the health outcomes of the diseases in question and impacts of related diseases. It mainly included risk factors for health and disease (such as atherosclerosis, metabolically healthy obesity, socioeconomic status, etc), as well as outcomes for different health conditions (such as all-cause mortality, stroke, diabetes, etc).[55] It also involved strategies for preventing and improving health conditions (such as the Mediterranean diet).[56] Together, the above factors form part of the global health burden and pose challenges for disease diagnosis, prevention, and treatment. Therefore, an in-depth exploration of the health problems represented by these keywords and their interrelationships is of great significance for formulating effective health policies and improving public health status.

After 2020, the research focus shifted to the intrinsic mechanisms and influencing factors between health and physiological indicators and diseases. (1) Cholesterol: Obesity is strongly associated with a variety of serious complications, including CVD, type 2 diabetes, and osteoarthritis.[57] These complications not only significantly reduce patients' quality of life, but also have a long-term negative impact on long-term health outcomes. Among them, dyslipidemia is one of the common metabolic disorder manifestations of obesity, especially elevated cholesterol levels. High cholesterol levels are an important risk factor for CVD, leading to hardening and narrowing of blood vessel walls, thereby increasing the risk of CVD.[58] (2) Non-alcoholic fatty liver disease (NAFLD): NAFLD is one of the common complications of obesity and is closely associated with the risk of cardiovascular diseases. NAFLD not only affects liver health, but may also exacerbate the risk of cardiovascular disease through mechanisms such as systemic inflammation and insulin resistance.[59] (3) Adipose tissue: The core issue of obesity is the excessive accumulation of adipose tissue. Adipose tissue not only stores energy, but also secretes a variety of hormones and inflammatory factors, which may exacerbate the risk of cardiovascular disease by affecting metabolism, inflammatory response, and other mechanisms. The next study can focus on the specific mechanism of the role of VAT in obesity-related cardiovascular risk, deeply analyze how its secreted adipokines and cytokines are involved in the pathological process, and explore effective interventions targeting VAT, with a view to providing a more precise scientific basis for the prevention and treatment of cardiovascular disease in

obese patients. (4) Oxidative Stress: Obesity is often accompanied by elevated levels of oxidative stress. Oxidative stress is one of the important pathogenic mechanisms of cardiovascular disease, which may exacerbate the progression of cardiovascular disease by damaging the blood vessel wall and promoting inflammatory responses.[60] (5) Chronic kidney disease: Obesity is also one of the important risk factors for chronic kidney disease. Chronic kidney disease not only affects renal function but may also exacerbate the risk of cardiovascular disease by affecting metabolism, inflammatory response, and other mechanisms.[61] (6) Ratio to height: This may refer to the ratio of weight to height, also known as body mass index (BMI). BMI is one of the most important indicators of obesity, which is closely related to the risk of cardiovascular disease. A high BMI often means a higher risk of cardiovascular disease.[62]

Therefore, obesity increases the risk of cardiovascular disease through a variety of mechanisms, including dyslipidemia, NAFLD, excessive accumulation of adipose tissue, oxidative stress, etc. Preventing and managing obesity is of great significance for reducing the risk of cardiovascular disease. So lifestyle interventions such as exercise and a healthy diet can effectively reduce the risk of obesity and its complications.

In summary, future research can focus on several key areas: precise diagnostic techniques, comprehensive intervention strategies, and mental health management, to promote interdisciplinary cooperation. Additionally, implementing intelligent health management will comprehensively improve the level of prevention and management. Furthermore, optimizing diagnostic methods to improve diagnostic accuracy, along with strengthening integrated interventions involving physical activity and lifestyle changes, and deepening the study of obesity paradoxes, will contribute to developing a more comprehensive cardiovascular health management strategy specifically tailored for obesity.

Advantages and Limitations

This study for the first time used bibliometrics methods to comprehensively incorporate the literature related to cardiovascular risk in obese patients in the past decade, and utilized software such as VOSviewer and Citespace to analyze the data systematically, providing a comprehensive insight into the current hotspots and frontiers of research.

However, our study also has several limitations that are worth further discussion and future improvement. Firstly, in terms of data source selection, this study mainly relied on Web of Science, a multidisciplinary and comprehensive database, to extract relevant literature, which inevitably may miss potentially important literature from other databases. This reliance on a single database may have limited the comprehensiveness of the study's coverage and prevented us from obtaining all relevant and valuable information in the field. Secondly, we only included the English language literature, which may have somewhat underestimated the contribution and influence of non-English language papers in the research field. Thirdly, our retrieval date was September 1, 2024, and the citation frequency of recently published literature tends to be still at a low level due to its short publication time. This may lead to some bias in assessing the impact and importance of the literature, which in turn may cause a certain degree of bias to the overall study results.

Conclusions

The study of cardiovascular risk in patients with obesity holds great academic value and practical application significance. In recent years, the rapid growth of the research literature in this field indicates that its importance has been widely recognized by healthcare workers around the world. However, looking at the current situation of global research, there is still a lack of effective mechanisms for collaborative research and academic exchanges between countries, and the phenomenon of fragmentation is more prominent; the collaboration on important medical problems needs to be strengthened urgently. Current research mainly focuses on disease mechanisms, complications, identification of risk factors, and exploration of intervention strategies. Although some progress has been made, there is still a lack of high-quality research that analyzes the complex relationship between obesity and cardiovascular health, which needs to be further explored. Notably, GLP-1 agonists have shown great potential in recent studies, providing new directions for the treatment of obesity and related cardiovascular diseases, and the breakthroughs of these drugs have opened up new areas for clinical practice and future research.

Future research should develop more comprehensive, precise and effective strategies for obesity cardiovascular health management through interdisciplinary cooperation, technological innovation and data sharing. Meanwhile, research should focus on the long-term effects and mechanisms of emerging therapies such as GLP-1 agonists, and optimize

personalized intervention strategies in combination with artificial intelligence technology, with a view to providing a stronger scientific basis for improving the quality of life of obese patients and reducing the morbidity and mortality of cardiovascular diseases worldwide.

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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.

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Disclosure

The authors declare that they have no conflicts of interest.

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