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THE EFFECTS OF RESISTANCE TRAINING ON OVERWEIGHT: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Objective: The aim of this study is to provide a thorough bibliometric analysis of resistance training methods in populations that are overweight. The objective is to present a comprehensive analysis of the present status of research on this particular topic and provide valuable recommendations to practitioners who are involved in this area. Materials and methods: We conducted a comprehensive analysis of the scientific literature on resistance training in overweight populations, covering the period from 1995 to 2024. A comprehensive search was performed in the Web of Science database using the keywords "resistance training" and "overweight." The search encompassed all pertinent information contained within the articles. The data were produced in BibTex format and then entered into the Bibliometrix program for analysis. Results: The examination showed that 60 countries and 281 periodicals published the 666 papers analyzed in this study between 1995 and 2024. Notable magazines include "Medicine and Science in Sports and Exercise" and the "Journal of Strength and Conditioning Research." The results also indicate substantial author collaboration and strong cooperation across countries, with the United States, Canada, Brazil, Australia, and Iran being the primary collaborating nations. Conclusions: Given the persistently high incidence of overweight, it is imperative to investigate exercise treatments that are effective. Recent research has indicated a growing interest in using resistance training as a means of addressing overweight issues. This upward trend is projected to persist in the future. This emphasizes the gravity of obesity as a matter of public health and showcases the efficacy of resistance training as an intervention strategy.

Key words. Resistance Training. Overweight. Bibliometric Analysis. Network Analysis. Trend Topic.

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RESUMO

Os efeitos do treino de resistência no excesso de peso: uma análise bibliométrica

Objetivo: O objetivo deste estudo é fornecer uma análise bibliométrica completa dos métodos de treinamento de resistência em populações com sobrepeso. O objetivo é apresentar uma análise abrangente do estado atual da pesquisa sobre este tema específico e fornecer recomendações valiosas aos profissionais que atuam nesta área. Materiais e métodos: Realizamos uma análise abrangente da literatura científica sobre treinamento de resistência em populações com sobrepeso, cobrindo o período de 1995 a 2024. Uma busca abrangente foi realizada na base de dados Web of Science usando as palavras-chave "resistance training" e "overweight." A busca abrangeu todas as informações pertinentes contidas nos artigos. Os dados foram produzidos em formato BibTex e depois inseridos no programa Bibliometrix para análise. Resultados: O exame mostrou que 60 países e 281 periódicos publicaram os 666 artigos analisados neste estudo entre 1995 e 2024. Revistas notáveis incluem "Medicine and Science in Sports and Exercise" e o "Journal of Strength and Conditioning Research." Os resultados também indicam uma colaboração substancial entre autores e uma forte cooperação entre países, sendo os Estados Unidos, Canadá, Brasil, Austrália e Irã as principais nações colaboradoras. Conclusão: Dada a incidência persistentemente alta de sobrepeso, é imperativo investigar tratamentos de exercício que sejam eficazes. Pesquisas recentes indicaram um crescente interesse no uso do treinamento de resistência como um meio de abordar questões de sobrepeso. Essa tendência crescente é projetada para persistir no futuro. Isso enfatiza a gravidade da obesidade como uma questão de saúde pública e destaca a eficácia do treinamento de resistência como uma estratégia de intervenção.

Palavras-chave: Treinamento de Resistência. Sobrepeso. Análise Bibliométrica. Análise de Rede. Tópico de Tendência.

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INTRODUCTION

In recent years, overweight and obesity have spread worldwide and have become one of the biggest global health risks (Popkin et al., 2012; Abdelaal et al., 2017; Swinburn et al., 2019). In the latest figures released by the World Health Organization, 2.5 billion adults (aged 18 and over) globally overweight (43%) in 2022, World Health Organization (WHO, 2024).

Research shows that overweight is a precondition for many major diseases (Afolabi et al., 2023). In 2019, higher-than-ideal BMI led to about 5 million deaths from non-communicable diseases (NCDs) World Health Organization (WHO, 2024).

Additionally, a high body mass index (BMI) is also a recognized risk factor for cancer (Pergola, Silvestris, 2013; Clinton et al., 2020). Studies have shown a significant increase in cancer-related deaths due to high body mass index globally from 2010 to 2019 (Tan et al., 2024).

Overweight and obesity have become significant contributors to the global burden of disease (Dai et al., 2020). It has a big effect on heart diseases (Piché et al., 2018), type 2 diabetes (GBD 2015 Obesity Collaborators, 2017), infertility (Gautam et al., 2023), and some types of cancer (Pergola, Silvestris, 2013), which makes people's health get worse very quickly.

With the increasing incidence of overweight individuals, it is crucial to investigate efficient techniques for enhancing their health. Studies have demonstrated that consistent engagement in physical activity can effectively manage weight and enhance general health (Shephard, 2019).

The predominant focus of recent research on exercise treatments for those who are overweight has been on aerobic exercise (Millstein, 2020), high-intensity interval training (Atakan et al., 2021), flexibility training (Noóbrega et al., 2005), and resistance training (Boyer et al., 2023).

Among these, resistance training has also garnered significant attention as an intervention. According to research conducted by Winett and Carpinelli including resistance training into public health promotion programs is highly recommended (Winett, Carpinelli, 2001).

Prior studies have indicated that resistance exercise might be beneficial for overweight and obese people by enhancing muscular strength and positively impacting physical functioning in this population (Jakicic, Otto, 2006).

According to the latest umbrella review, resistance training is a highly adhered to and safe form of exercise intervention. It significantly improves body fat percentage and is an excellent option for overweight or obese individuals with low cardiorespiratory fitness (Xinyu et al., 2024).

In summary, resistance training, which includes exercises like weightlifting and bodyweight exercises, increases muscle growth and strength, elevates basal metabolic rate, stimulates fat oxidation, and improves overall physical performance (Campbell et al., 1994; Skelton et al., 1995; Westcott, 2015).

Additionally, It promotes the reduction of subcutaneous adipose tissue, which reduces the risk of various cardiovascular diseases and also promotes improved aerobic endurance (Myrtaj et al., 2022).

However, there are certain disadvantages related to this approach. It tends to prioritize performance, which may not be suitable for individuals who are overweight or obese (Hills et al., 2010).

Additionally, beginners and those who are overweight or obese may require guidance and supervision to ensure both safety and effectiveness (Sothern et al., 2000).

Resistance training is a crucial intervention for overweight populations. However, there is a shortage of quantitative bibliometric analyses to effectively summarize the advancements in research on resistance training therapies for overweight individuals in recent years.

Bibliometric analysis, encompassing various mathematical and statistical techniques, is a robust quantitative research method that offers an objective framework for tracking the evolution and structural composition of knowledge within a specific field (Ellegaard, Wallin, 2015; Lou et al., 2023).

Researchers in a variety of fields, such as pain management, diabetes, dyslexia, depression, and cancer rehabilitation, have applied bibliometrics in recent years (Stout et al., 2018; Wang et al., 2019; Zhang et al., 2021; Zhang et al., 2022).

To our knowledge, despite a growing body of research on resistance training and overweight, no bibliometric analyses have yet been conducted in this field (Zhang et al., 2021).

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Findings from such bibliometric studies can assist researchers in identifying current research concerns and guiding future research directions.

Due to its significant advantages, the application of bibliometric methods in the field of research on exercise interventions for overweight people is of immense value. In this study, we aimed to conduct a comprehensive bibliometric analysis of intervention studies of resistance training in overweight populations.

The focus is on a careful review of past studies and an assessment of the current state in terms of the current stage of development of resistance training for overweight populations, social networks, and keyword analyses.

MATERIALS AND METHODS

We did a comprehensive examination of research areas and published works about resistance training in persons who are overweight.

We conducted a comprehensive search of the Web of Science database from 1995 to 2024 to identify all the scientific articles related to resistance training in overweight adults. Subsequently, we collected the relevant data and presented it in Figure 1.

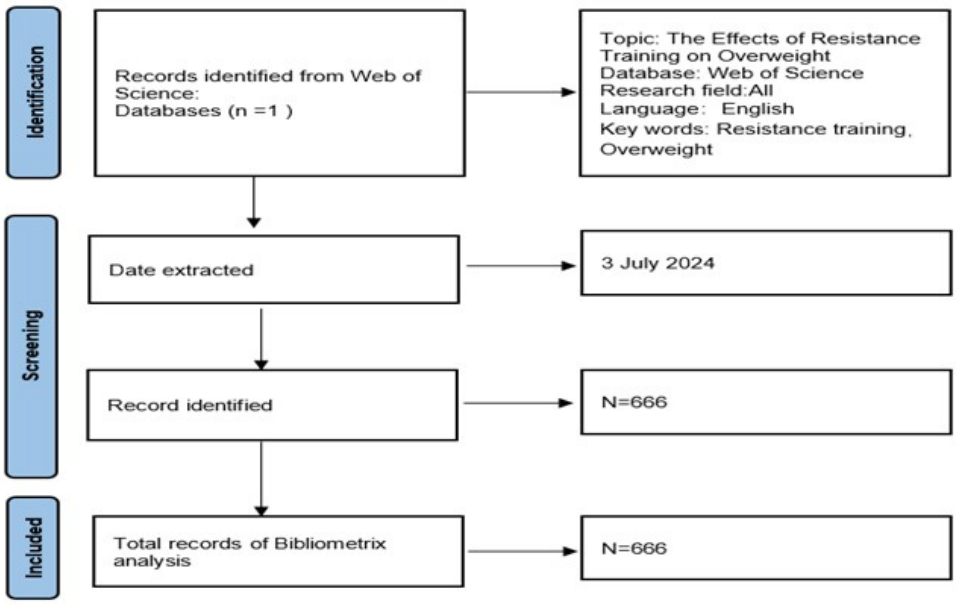

Figure 1 - Flowchart of the publications selection.

The database of the Scientific Network was searched. Scientific publications, included in the platform's most complete connected data set (Bergeron et al., 2018).

To find the English documentation, we used "resistance training" and "overweight" in the title, summary and keyword fields from all. In this research, only the keywords "resistance training" and "overweight" were identified and analyzed, and no other synonyms were involved.

We used some exclusion criteria. Use the Bibliometrix program to download data in BibTex format, filter it, and then check it (Sjöberg et al., 2020).

It is currently considered to be the most comprehensive, integrated and user-friendly Type A. Belfiore et al bibliometric tool, it is an open-source tool for scientific measurement and quantitative research of book measurements (Kang et al., 2021).

Open the R run environment and enter "bibliometrix::biblioshiny".Run the code, pop up a network window, click "import row file(s)" on the data loading page, select the database type "Web of Science", load the previously filtered literature data, and click the Start button. Bibliometrix offers a wide range of scientific metrics methods for analyzing bibliometric data. Some of the scientific metrics methods available in Bibliometrix include:

•Bibliometric analysis: Bibliometrix can analyze the quantity, type, year, authorship, publication, citation, and citation network of literature

•Collaboration analysis: Bibliometrix can analyze collaboration patterns, such as author

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and country collaboration, collaboration networks, and collaboration topics
•Word frequency analysis: Bibliometrix can perform text mining and word frequency analysis to identify the most frequent words and topics used in literature
•Topic modelling: Bibliometrix can use topic modelling techniques to classify and summarize the literature, revealing potential topics within the literature.
•Citation analysis: Bibliometrix can analyze how literature is cited, including the number, time, source, type, and field of citations.
•Social network analysis: Bibliometrix can perform social network analysis to identify key people and organizations in authorship, publication, and citation networks and reveal their relationships and influence.
•Visualization analysis: Bibliometrix can visualize the results of the above analyses, allowing users to more intuitively understand trends and patterns in bibliometric data.

The article analyzes Bibliometrix's measurement approaches to analyze and judge the feasibility and future trends in the discipline through intuitive scientific analysis.

RESULTS

Main information

The analysis of all retrieved articles, as shown in Table 1, indicates that the literature investigating the impact of resistance training on overweight covers a wide time span (1995 to 2024).

A total of 666 documents were found, originating from 281 distinct journals or books. The literature experiences an annual growth rate of 10.26%, with an average of 31.29 citations per article. This indicates a significant level of activity and effect in research within this topic.

The majority of the retrieved publications were written by many authors, with an average of 7.16 co-authors per document. Additionally, 26.73% of these partnerships were international in nature. This data unveils the research trends and patterns of collaboration in resistance training as a response to the issue of overweight. It serves as a good foundation for doing more detailed studies.

Table 1 - Main information about data.

Description	Results
Timespan	1995:2024
Sources (Journals, Books, etc)	281
Documents	666
Annual Growth Rate %	10.26
Document Average Age	7.52
Average citations per doc	31.29
References	21463
Keywords Plus (ID)	1469
Author's Keywords (DE)	1100
Authors	3474
Authors of single-authored docs	16
Single-authored docs	17
Co-Authors per Doc	7.16
International co-authorships %	26.73

Analysis of scientific production, trends and citations of various countries

The research output from various countries demonstrates a diverse landscape, highlighting significant contributions in this field. As presented in Table 2 and Figure 2, the scientific output from different countries between 1995 and 2024 shows clear trends. The United States has exhibited significant growth, especially since 2009, with the number of publications increasing markedly, reaching

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976 articles in 2024, indicating its dominance and strong research productivity in this field. Canada's research output has gradually increased from 1 article in 1995, with rapid growth after 2009, reaching 474 articles in 2024, showing a consistent and robust academic output. Brazil, Australia, and Iran have also contributed 258, 250, and 185 articles, respectively, each showing varying degrees of growth, reflecting differences and dynamic changes in research investment and output across countries, and demonstrating their active participation in the global scientific community. European countries such as Finland (141 articles), Spain (140 articles), and the United Kingdom (98 articles) have maintained strong positions, while China (92 articles) and other Asian countries such as South Korea (46 articles) and India (30 articles) have shown steady growth, contributing significantly to research in this field. These data highlight the widespread distribution of scientific output globally, with most countries showing keen interest in research on resistance training interventions for overweight populations. North American countries dominate in research output, while other regions show gradual growth and efforts to catch up.

Table 2 - Countries' Scientific Production and Citations.

Country	Freq	TC	Average Article Citations
USA	976	6693	37.6
CANADA	474	2556	41.2
BRAZIL	258	670	13.1
AUSTRALIA	250	2662	47.5
IRAN	185	369	7.5
FINLAND	141	686	45.7
SPAIN	140	599	19.3
UK	98	258	17.2
CHINA	92	188	8.5
FRANCE	90	370	28.5
ITALY	81	606	46.6
GERMANY	64	147	12.2
CHILE	63	55	6.9
NORWAY	60	162	13.5
PORTUGAL	46	15	3
SOUTH KOREA	46	219	24.3
SOUTH AFRICA	39	43	6.1
COLOMBIA	32	83	20.8
INDIA	30	143	20.4
GREECE	23	248	62

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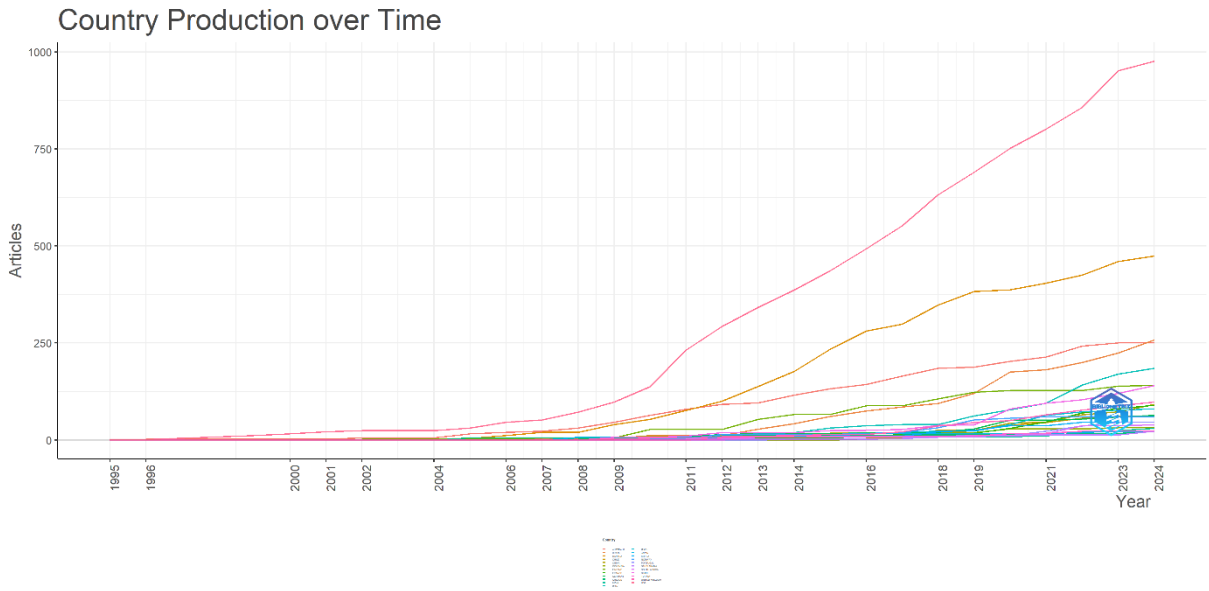

Fi**gure 2 -** Countries' Production over Time.

Upon examining the statistics in Table 2 about the Most Cited Countries, it is evident that Turkey holds the fourth position with a total citation count of 847. Nevertheless, it outperforms other countries with an average of 169.4 citations per paper, demonstrating significant impact in the realm of research. Singapore and Austria have average citation counts of 108 and 105, respectively, indicating their significant visibility and influence in particular areas.

Brazil and Iran, on the other hand, have lower average citation counts of 13.1 and 7.5, respectively, although they contribute to the overall number of citations.

This suggests that their research effect is considerably smaller. The United States ranks first on the list with a total citation count of 6693, highlighting its extensive academic activity and influence. Australia and Canada rank second and third, respectively, with 2,662 and 2,556 total citations, underscoring the substantial impact of these two nations in the field of academic research. Together, these statistics demonstrate the diverse roles and effects of different nations in the academic field, highlighting their skills and significance in certain study fields.

Analysis of the amount of journal publications and their changes over time

With 36 and 27 respective relevant articles published, Table 3 shows that " MEDICINE AND SCIENCE IN SPORTS AND EXERCISE " and the " JOURNAL OF STRENGTH AND CONDITIONING RESEARCH " are the top publications in the subject of resistance training for overweight. Other publications with high publishing frequency in this field are " OBESITY," " FRONTIERS IN PHYSIOLOGY," and " APPLIED PHYSIOLOGY NUTRITION AND METABOLISM." These sources, which include exercise physiology, nutrition, and public health and therefore highlight the interdisciplinary character of research in this subject and emphasize the need of thorough and varied study methodologies in understanding and combating obesity.

Furthermore, the International Journal of Environmental Research and Public Health and Nutrients are frequently cited, indicating that public health and nutrition are significant aspects in the investigation of the impact of resistance training on overweight individuals. The publications often demonstrate the exceptional quality of research in this field. Collectively, these periodicals exemplify the wide range and intricate nature of the study domain, underscoring the significance of interdisciplinary cooperation.

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Table 3 - Most Relevant Sources.

Sources	Articles
MEDICINE AND SCIENCE IN SPORTS AND EXERCISE	36
JOURNAL OF STRENGTH AND CONDITIONING RESEARCH	27
APPLIED PHYSIOLOGY NUTRITION AND METABOLISM	18
FRONTIERS IN PHYSIOLOGY	15
OBESITY	15
INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH	13
MEDICINE & SCIENCE IN SPORTS \& EXERCISE	13
NUTRIENTS	13
JOURNAL OF SPORTS MEDICINE AND PHYSICAL FITNESS	11
OBESITY REVIEWS	10
PLOS ONE	9
BMC SPORTS SCIENCE MEDICINE AND REHABILITATION	8
PHYSIOLOGY \& BEHAVIOR	8
REVISTA BRASILEIRA DE MEDICINA DO ESPORTE	8
DIABETES CARE	7
JOURNAL OF APPLIED PHYSIOLOGY	7
CONTEMPORARY CLINICAL TRIALS	6
EUROPEAN JOURNAL OF APPLIED PHYSIOLOGY	6
INTERNATIONAL JOURNAL OF OBESITY	6
JOURNAL OF SPORTS SCIENCES	6

Analysing the data from 1995 to 2024, as presented in Figure3, there has been a gradual increase in the number of academic studies on the effects of resistance training on overweight populations, with a significant increase in the number of published articles, especially in the last decade. For example, "MEDICINE AND SCIENCE IN SPORTS AND EXERCISE" had only 1 paper per year between 1995 and 2000, but has stabilised at around 36 papers per year by 2024. Similarly, the number of papers in "JOURNAL OF STRENGTH AND CONDITIONING RESEARCH" has increased from 1 in 2005 to 27 in 2024.

In addition, emerging journals such as "FRONTIERS IN PHYSIOLOGY" and "INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH" also show rapid growth." FRONTIERS IN PHYSIOLOGY" started publishing relevant research papers in 2018 and reached 15 papers per year in 2024. While "INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH" has shown a significant increase from 2020 and reaches 13 relevant papers per year by 2024. Other journals such as "NUTRIENTS" and "PLOS ONE" show similar growth trends, indicating that the expanding research interests and diversification of scholarly resources have led to a growing body of knowledge in the field. Overall, all major journals have increased their focus on the relationship between resistance training and overweight over the past two decades, reflecting the growing depth and development of research in the field.

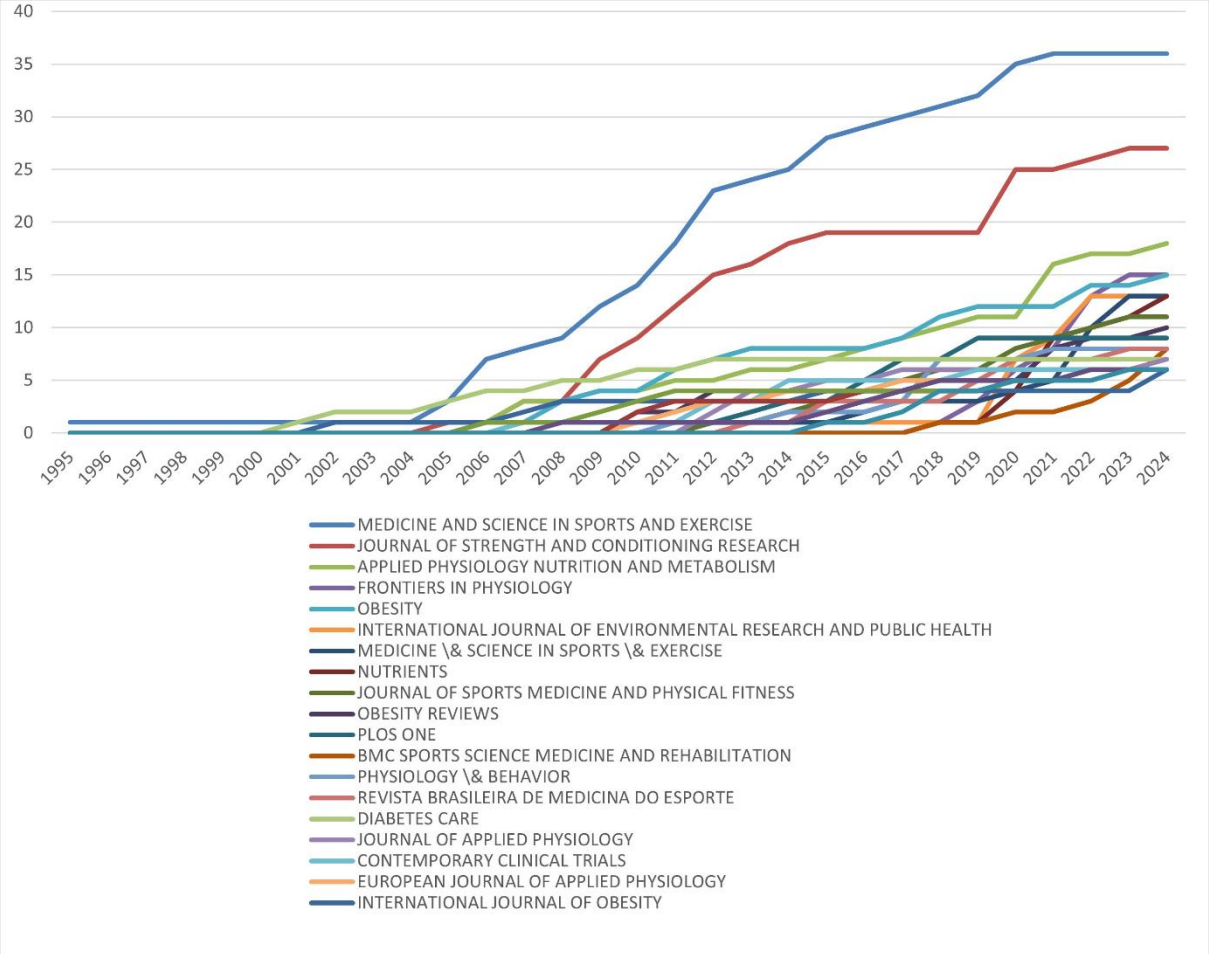

Figure 3 - Sources' Production over Time.

Analysis of annual scientific production and citation data

According to annual scientific output data from 1995 to 2024, research on the effects of resistance training on overweight has grown significantly. As shown in Figure 4, starting with two publications in 1995, there was a gradual increase from 2005 onward, reaching 44 publications in 2012. Between 2013 and 2024, research maintained steady growth, particularly peaking at 56 and 60 articles in 2020 and 2022, respectively, demonstrating the growing interest and activity in this area of research.

Although the data for 2024 is not yet complete, 34 publications are available, indicating that research continues to advance. Overall, research on the effects of resistance training on overweight has experienced rapid growth from its beginnings over the past few decades and has reached a research peak in the last few years. The depth and breadth of research have increased over time, providing the field with a wealth of scholarly resources.

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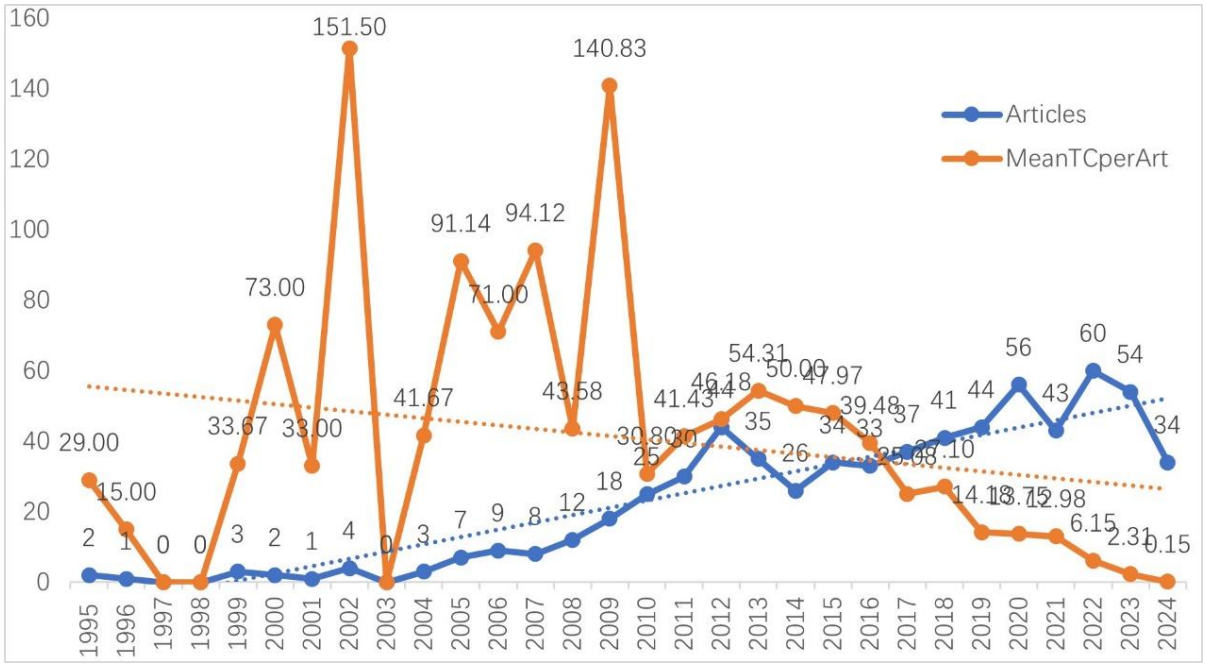

Figure 4 - Annual scientific production and citation data.

Based on the average annual citation data from 1995 to 2024, the literature exhibited high citation rates in the early (1995-2004) and middle (2005–2014) phases, especially in 2002 and 2009, when they peaked at 151.50 and 140.83, respectively.

However, in recent years (2015–2024), the average citation rate has shown a decreasing trend, especially after 2022, when the citation rate is significantly lower. This trend may reflect the fact that the recent literature has not yet accumulated enough citations or a shift in research hotspots.

As presented in Table 4, high-impact literature related to resistance training and overweight is analyzed based on total citations (TC), average citations per year (TC per Year), and normalized citation counts (Normalized TC). Donnelly et al. (2009) published in "MED SCI SPORTS EXERC" has the highest total citations (1685), demonstrating significant influence in the field of resistance training, with an average of 105.31 citations per year and a normalized citation count of 11.96. Yumuk et al. (2015) in "OBES FACTS" have fewer total citations (771), yet they exhibit relatively high average citations per year (77.10) and a normalized citation count of 16.07, indicating their novelty and high impact within a shorter timeframe. Dobbins et al. (2013) in "COCHRANE DATABASE SYST REV" also show significant impact with an average of 53.33 citations per year.

Other highly cited papers such as Dunstan et al. (2002), Moro et al. (2016), and Lakka et al. (2007), while having fewer total citations, demonstrate their academic value in specific fields through normalized citation counts.

These high-impact publications not only highlight key contributors in the research fields of resistance training and overweight but also reveal relative influences across different times and contexts. They showcase trends in resistance training research for overweight management and provide crucial references for future studies.

Table 4 - Most Global Cited Documents

Paper	Total Citations	TC per Year	Normalized TC
DONNELLY JE, 2009, MED SCI SPORTS EXERC	1685	105.31	11.96
YUMUK V, 2015, OBES FACTS	771	77.10	16.07
DOBBINS M, 2013, COCHRANE DATABASE SYST REV	640	53.33	11.78
DUNSTAN DW, 2002, DIABETES CARE	478	20.78	3.16
MORO T, 2016, J TRANSL MED	406	45.11	10.28
LAKKA TA, 2007, APPL PHYSIOL NUTR METAB	307	17.06	3.26
ARTERO EG, 2012, J CARDIOPULM REHABIL PREV	305	23.46	6.60
SWIFT DL, 2018, PROG CARDIOVASC DIS	249	35.57	9.19
WILLIS LH, 2012, J APPL PHYSIOL	248	19.08	5.37
MANUEL FERNANDEZ-REAL J, 2009, J CLIN ENDOCRINOL METAB	232	14.50	1.65
LAYMAN DK, 2005, J NUTR	229	11.45	2.51
SHAIBI GQ, 2006, MED SCI SPORTS EXERC	228	12.00	3.21
KLINE CE, 2011, SLEEP	218	15.57	5.26
ISMAIL I, 2012, OBES REV	215	16.54	4.66
HO SS, 2012, BMC PUBLIC HEALTH	179	13.77	3.88
HEINRICH KM, 2014, BMC PUBLIC HEALTH	179	16.27	3.58
COURNEYA KS, 2014, MED SCI SPORTS EXERC	178	16.18	3.56
OLSON TP, 2007, INT J OBES	177	9.83	1.88
SMITH JJ, 2014, PEDIATRICS	166	15.09	3.32
FATOUROS IG, 2005, J CLIN ENDOCRINOL METAB	165	8.25	1.81

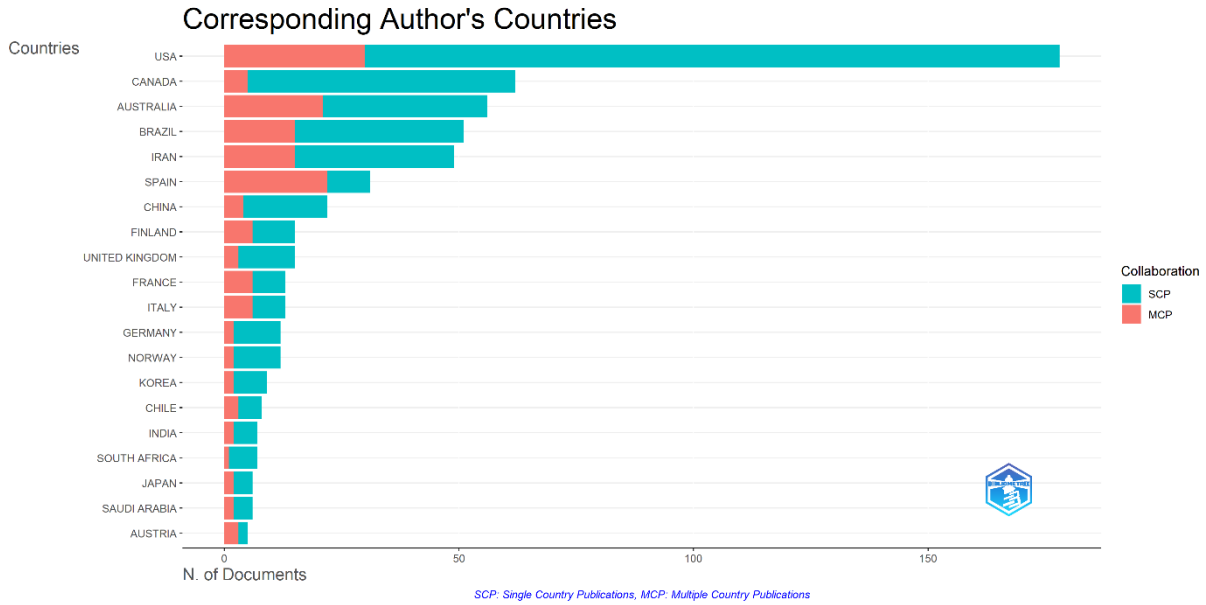

Figure 5 - Corresponding Author's Countries.

Analysis of collaboration networks

Country collaborative analysis

Figure 5 displays the quantity of co-authored publications by nation and their corresponding fractions, providing insight into the influence and involvement levels within this study domain. The United States (USA) has the highest number of articles, with 178, which accounts for 26.7% of the total. Canada follows with 62 articles, or 9.3%. Australia and Brazil exhibit noteworthy global production with 56 and 51 pieces respectively, representing 8.4%

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and 7.7%. Participating actively in academic research, Iran, Spain, and China each provide 49, 31, and 22 papers, respectively. Though less common, nations such as Finland, the United Kingdom, France, and Italy show focused contributions reflecting their expertise in particular sectors. These results provide an insightful analysis of the scholarly production and distribution among many countries in this field of study, thereby guiding future investigations of worldwide cooperation and academic influence.

Through careful examination of international cooperation-as shown in Table 5- we may discover complex networks of scientific cooperation and their underlying drivers. In global scientific research projects, the United States has demonstrated great impact and radiating power. This is evident not only in its extensive engagement with nations like Australia (24), Brazil (16), Iran (13), Spain (13), Canada (11), and the United Kingdom (11), but also in its significant contribution to global scientific research collaboration. The US's supremacy helps us to explain its remarkable excellence in infrastructure, money, and scientific research tools.

Particularly in its regular interactions with Chile (15 times) and Colombia (11 times), Spain is a major hub for cooperation. This cooperation may be inspired by shared language and cultural traits, in addition to historical links. Spanish scientific institutions are probably more common in Latin America, which facilitates their cooperation with local organizations.

Australia exhibits a significant level of collaboration with the UK (8), as well as a robust level of collaboration with the US (24). The similarity in research policy, culture, and language among Commonwealth nations may contribute to reducing barriers to cooperation and enhancing the efficiency of collaboration.

Table 5 - Countries' Collaboration

From	To	Frequency
USA	AUSTRALIA	24
USA	BRAZIL	16
SPAIN	CHILE	15
USA	IRAN	13
USA	SPAIN	13
SPAIN	COLOMBIA	11
USA	CANADA	11
USA	UNITED KINGDOM	11
AUSTRALIA	UNITED KINGDOM	8
CHILE	COLOMBIA	7
IRAN	FRANCE	7
USA	FRANCE	7
UNITED KINGDOM	FRANCE	6
UNITED KINGDOM	SWITZERLAND	6
BRAZIL	PORTUGAL	5
CANADA	AUSTRALIA	5
CANADA	FRANCE	5
FINLAND	SWEDEN	5
FRANCE	NETHERLANDS	5
FRANCE	TUNISIA	5

There is a significant level of collaboration within Europe, particularly between the UK and France (6 occasions) as well as Switzerland (6 instances). Noteworthy collaboration is also observed between France and the Netherlands (5 instances) and Tunisia (5 instances). These relationships are expected to be motivated by EU research initiatives and framework programmers, since the EU offers several chances for collaboration and financial assistance to member states and affiliated nations. Furthermore, the collaboration between France and Tunisia may also signify the presence of intellectual connections and historical ties among French-speaking nations. The collaborations between South America and Europe, particularly the Brazil-Portugal cooperation, are significant. This collaboration, which has occurred five times, is not only based on language similarities but also influenced by

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historical and cultural connections between the two nations. Canada, a prominent participant in research, has actively engaged in transcontinental research collaboration with Australia (on 5 occasions) and France (on 5 occasions).

The collaboration between the Nordic nations, particularly Finland and Sweden, is noteworthy due to their geographical proximity, cultural similarities, and strong connections between their research systems. This collaboration has occurred five times. The strong cooperation among these nations in terms of research policy, academic exchanges, and research funding has facilitated the advancement of scientific knowledge in the area. In Asia, there is limited cooperation among countries like China, Japan, Korea, and India. However, there are a few noteworthy collaborations. For instance, China has partnerships with Italy and Korea, while India has collaborations with Austria, Egypt, and Greece.

These cooperation data generally show the great scope and complexity of international scientific cooperation, as well as the active participation of countries in the field of research on overweight and resistance training. Combining the data, it is clear that North America, Europe, and Oceania show stronger alliances, suggesting that academic research in these nations has great potential for international cooperation.

The regular cooperation between the United States and Australia shows tremendous fit and preparedness to operate in specialized research domains like medical, science, and technology. With a heavy focus on international partnerships concentrated on the United States, the United Kingdom, and Australia, the data show generally the existence of a worldwide network of partnerships in scholarly research. These joint projects not only show the close ties between countries for scientific research but also provide a vital basis for future worldwide collaboration.

International collaboration, resource pooling, technological exchange, and invention dispersion have all contributed to global sectoral progress. Language, culture, history, law, and geography all help to define the founding and survival of these cooperative alliances. Advancing world cooperation in research and raising world research output depend on a thorough awareness of these fundamental elements.

Table 6 - Most Relevant Authors

Authors	Articles	Articles Fractionalized
ALBERGA AS	18	1.97
GOLDFIELD GS	18	1.61
KENNY GP	18	1.92
SIGAL RJ	18	1.86
PRUD'HOMME D	17	1.58
MARSH AP	14	1.88
CROYMANS DM	12	2.76
LUBANS DR	12	2.25
HADJIYANNAKIS S	11	0.92
KRAUS WE	11	0.95
NICKLAS BJ	11	1.46
ROBERTS CK	11	2.66
HUNTER GR	10	2.05
RABASA-LHORET R	10	1.40
IZQUIERDO M	9	1.14
J. J	9	1.05
PHILLIPS P	9	0.75
BALES CW	8	0.61
CAMERON JD	8	0.70
CAMPBELL WW	8	1.72

Analysis of author collaboration

An extensive examination of the data pertaining to the most significant writers enables us to uncover the scientific ecosystem and academic connections of these scholars in the domain of overweight and resistance training, as presented in Table 6. ALBERGA

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AS, GOLDFIELD GS, KENNY GP, and SIGAL RJ all produced 18 publications, demonstrating their high level of activity in scientific study within this discipline. Their exceptional productivity might be ascribed to their positions of leadership within specialized research organizations or their active participation in several extensive research initiatives and joint research endeavors. Specifically, ALBERGA AS and KENNY GP, with respective contributions of 1.97 and 1.92 after allocation, demonstrate that they not only produced a substantial quantity of publications, but also played a significant role in each of them.

GOLDFIELD GS and SIGAL RJ, although also publishing 18 articles, have relatively low articles fractionalised (1.61 and 1.86), which may indicate that they are more involved in collaborative research projects rather than leading all of them. PRUD'HOMME D published 17 articles, articles fractionalised at 1.58, demonstrating its importance in the field, and although slightly behind the top four in terms of the number of articles, it is still a key researcher in the field.

The contributions of MARSH AP and CROYMANS DM are also very noteworthy. MARSH AP published 14 articles, articles fractionalised at 1.88, demonstrating his importance in scientific research. CROYMANS DM, although he published 12 articles, had a high articles fractionalised of 2.76, suggesting that he made a very significant contribution to each article and may have been a key driver of some of the core research. LUBANS DR and ROBERTS CK also published 12 and 11 articles respectively. published 12 and 11 articles with ARTICLES fractionalised at 2.25 and 2.66, showing their key role in the research team. They may be responsible for guiding the direction of research, designing experimental protocols, or writing papers, all of which are integral parts of scientific research.

HADJIYANNAKIS S and KRAUS WE, despite each having published 11 articles, exhibit relatively lower articles fractionalized scores (0.92 and 0.95 respectively). This suggests that they may play secondary roles in more collaborative research endeavors, or their research interests are dispersed across multiple different research teams. In contrast, NICKLAS BJ (11 articles, fractionalized score 1.46) and HUNTER GR (10 articles, fractionalized score 2.05) demonstrate higher articles fractionalized scores, indicating their greater impact within their respective research contributions. Authors with a smaller number of published publications, like PHILLIPS P (9 articles, fractionalized score 0.75) and BALES CW (8 articles, fractionalized score 0.61), may have a lower total output, but their research still makes a major contribution to the field's progress. These data indicate that individuals could possess expertise in particular topics or initiatives, offering valuable insights and making significant contributions to the data.

Overall, the scholarly actions of these academics demonstrate both their own academic accomplishments and the academic connections and collaborations within the fields of overweight and resistance training. Highly productive researchers frequently assume critical positions in several initiatives, propelling progress in their subject and facilitating collaboration and information sharing among colleagues. This data aids in identifying prominent individuals in the area and potential collaboration opportunities, thereby promoting scientific advancement on a global scale.

Betweenness is a metric that quantifies the importance of a node acting as a network connector. Nodes that have a high Betweenness Centrality measure sometimes serve as connectors between different cooperation groups or play crucial roles in the distribution of information. Identifying these nodes can assist in identifying strategically positioned scholars in the cooperation network who may have significant roles throughout the whole research area. Closeness gauges the degree of a node's close connection to other nodes within a network. In a collaboration network, nodes with high closeness can quickly access and distribute information, which leads to improved cooperation and scholarly exchange efficiency. These nodes frequently have extensive collaborative networks within the study area and can act as crucial hubs for information flow. PageRank evaluates the impact and frequency of citations for nodes in a collaborative network. Nodes with high page rank often indicate scholars who have a substantial impact in the academic domain. Scholars frequently reference and debate these researchers' discoveries and viewpoints. These nodes enhance the collaboration network's stability and academic standing.

Figure 6 shows that Kraus WE and A. A. have a significantly high betweenness centrality in the collaboration network. This indicates that they play a critical role in connecting various collaborative groups and facilitating the flow and exchange of

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information. Prud'homme D's strong scores in PageRank and Closeness Centrality suggest that he has a significant position in terms of academic impact and information distribution. This makes him a potentially valuable collaborator on your study topic. The cooperation network consists of several clusters, including Cluster 1 and Cluster 8, which are likely to represent separate collaborative teams or research groups. An in-depth analysis of the distinctive features and patterns of collaboration within each cluster will help evaluate their potential influence on your study. Interdisciplinary cooperation nodes, such as Lubans DR and Morgan PJ, emerge within the collaboration network, offering opportunities for interdisciplinary research collaboration, namely in the areas of exercise physiology and obesity studies.

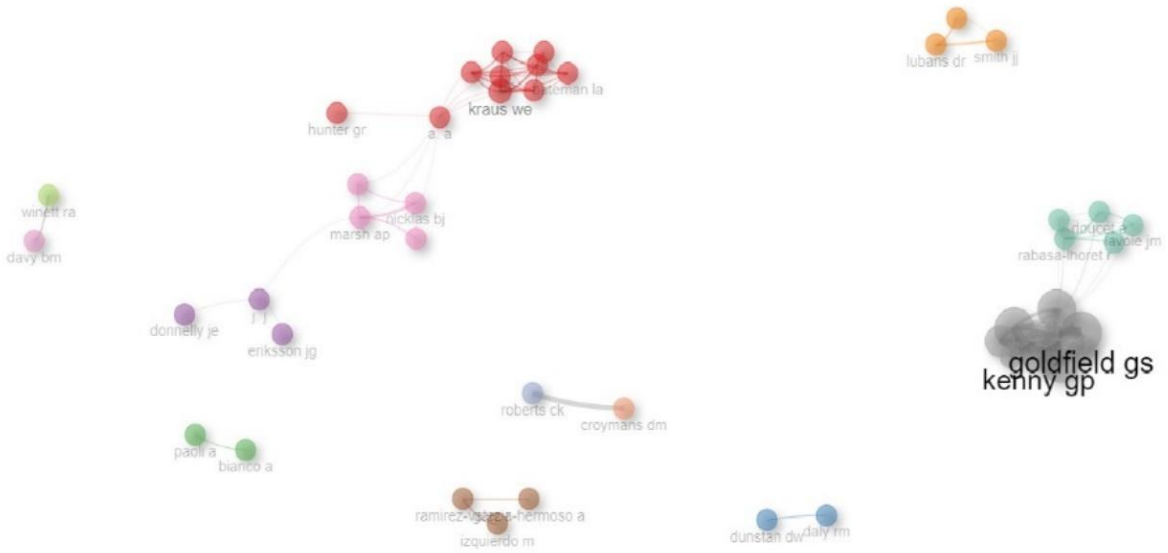

Figure 6 - Author Collaboration Network.

Based on the analysis results, it is advisable to consider deepening collaborations with researchers who possess high impact and extensive collaborative networks to enhance the visibility and influence of research outcomes in the academic community. According to the collaboration network analysis, Kraus WE and A. A demonstrate significant Betweenness centrality, suggesting they may play crucial bridging roles across different collaboration groups, facilitating information dissemination and cooperation. Prud'homme D exhibits high PageRank and Closeness centrality values, indicating prominent positions in academic influence and information flow, potentially serving as key collaborators. Multiple clusters within the collaboration network (e.g., Cluster 1 and Cluster 8) illustrate the existence of diverse collaboration teams, offering opportunities for interdisciplinary cooperation, particularly in the fields of exercise physiology and obesity studies. In conclusion, a thorough understanding and utilization of these collaboration network data will help optimize collaboration strategies, enhancing research impact and sustainable development in academia.

Analysis of keywords

Most Frequent Words

Based on the provided data, analyzing the frequency of these most common words reveals the current hotspots and focal points within the related research field, as presented in Table 7 and Figure 7. "Exercise" (235 occurrences) and "physical-activity" (214 occurrences) are the most frequently occurring terms, reflecting sustained attention to their importance in health and metabolic regulation. "Overweight" (224 occurrences) and "obesity" (82 occurrences) demonstrate research focus on issues of overweight and obesity, which have significant global implications for public health.

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Table 7 - Most Frequent Words

Words	Occurrences
exercise	235
overweight	224
physical-activity	214
weight-loss	121
body-composition	115
strength	103
obesity	82
children	65
insulin-resistance	64
resistance	61
health	60
women	54
metabolic syndrome	53
skeletal-muscle	53
fitness	50
risk	49
older-adults	48
adults	46
insulin sensitivity	45
risk-factors	43

Figure 7 - Word Cloud.

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Trend Topics

According to the trend topics data supplied, as shown in Figure 8, we can see the progression of different study subjects. Subjects such as Exercise and Physical-Activity have shown substantial growth since 2013, indicating a rising interest and extensive investigation into their effects on health.

Research on Weight-Loss and Body-Composition has tended to increase after 2013, reflecting continued societal interest in health management and weight loss strategies. The issue of obesity and overweight has gained increased attention since 2013, with a growing number of linked studies conducted each year as research has advanced.

There has been a notable rise in the quantity of research conducted on Weight-Loss and Body-Composition in recent years, which indicates the ongoing public fascination with health management and weight loss methods. The quantity of research on Weight-Loss has surged in recent years, indicating the ongoing cultural fascination with weight loss procedures. Recent years have seen a considerable growth in research on children and older individuals, indicating a growing interest and emphasis on health management across various age groups. Since 2012, there has been a consistent increase in research focused on Strength and Resistance training, emphasizing the importance of these topics in the area of sports science.

Recent years have witnessed significant advancements in the study of insulin resistance and metabolic rate, reflecting an increasing emphasis on metabolic health and conditions like diabetes. Studies on Cardiovascular Disease (CVD) and its correlated risk factors have demonstrated a steady annual increase since 2012, indicating the need for ongoing attention to the management of cardiovascular health. Health and physical activity research has experienced a substantial surge in recent years. This demonstrates a pervasive desire for methods to advance health and public health policy.

In summary, these trend topics demonstrate the progressive development of the exercise science and health management disciplines, transitioning from basic exercise treatments to more intricate investigations of health impacts and long-term health management methods. Advancements in research methodology and a deeper understanding of health consequences will lead to an increase in comprehensive multidisciplinary studies in the future, exploring various approaches to enhance human health and quality of life.

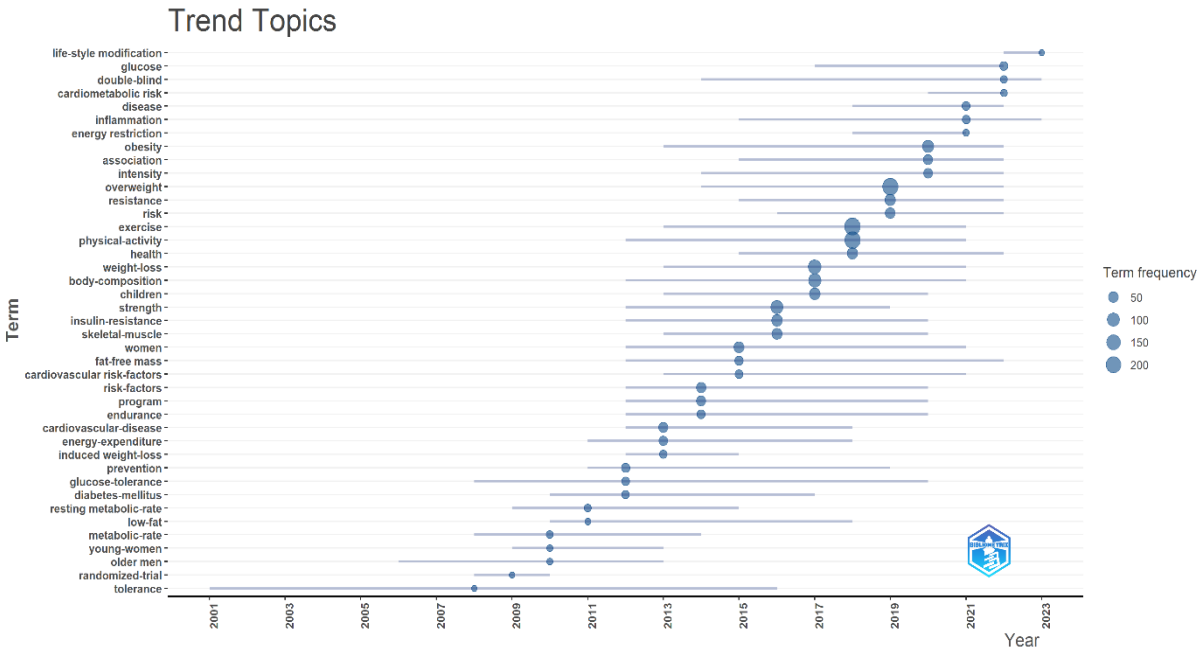

Figure 8 – Trend Topics.

DISCUSSION

A review of the literature on resistance training therapies for overweight people using bibliometric methods demonstrates a notable rise in research output between 1995 and 2024.

This trend highlights the increasing attention and acknowledgment among researchers about the significance of resistance exercise for overweight people.

On a global scale, this trend demonstrates a growing focus on the widespread problem of excessive weight and obesity, emphasizing the need for efficient intervention strategies.

Leading sources of influential research in this particular discipline include notable academic publications like "Medicine and Science in Sports and Exercise" and the "Journal of Strength and Conditioning Research".

These magazines are critical for spreading new discoveries and improving comprehension of the benefits of resistance exercise for overweight people.

Their existence highlights the scientific community's dedication to a better understanding of the advantages of resistance training. It provides researchers with opportunities to share their findings and supports the growing amount of data on resistance training.

The examination of social networks uncovers robust collaboration and intricate connections across researchers, institutions, and nations, underscoring the predominant position and impact of the United States in global research collaboration.

This is demonstrated by its regular partnerships with Australia, Brazil, Iran, Spain, Canada, and the United Kingdom. Collaborative endeavors are essential for progressing research and developing comprehensive ways to tackle overweight and obesity.

These collaborations are crucial for the advancement of the subject since they enable the sharing of ideas, resources, and expertise. The primary countries that have made significant contributions to resistance training for overweight populations are the United States, Canada, Brazil, Australia, and Iran.

These nations have taken prominent roles in doing research on resistance training for overweight people, demonstrating their dedication to solving the obesity problem. The spatial distribution of research highlights the worldwide recognition of obesity concerns and the necessity for efficient intervention approaches. The involvement of several nations underscores the broad applicability of resistance training as a method for addressing overweight and obesity. Keyword analysis is a method used to identify prevalent patterns and developing patterns in research.

The main topics covered include the impact of resistance training on health outcomes, the tactics used for interventions, and the physiological impacts it has on the body. Current trends focus on the continuous progress in developing novel intervention techniques and studying the enduring impacts of resistance training.

CONCLUSION

An examination of the literature from 1995 to 2024 reveals a noticeable increase in research focused on the impact of resistance training on overweight. This indicates a growing acknowledgment of resistance training as a significant intervention in addressing overweight and obesity.

To summarize, resistance training is a crucial intervention for enhancing group composition and general health in overweight adults. The expanding corpus of research in this field offers significant perspectives and recommendations for next investigations, eventually enhancing health outcomes and quality of life in persons with excess weight. Continual research and collaboration are essential for furthering our comprehension of resistance training and its significance in the management of overweight and obesity.

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The authors declare no conflicts of interest.

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