IZMIR DEMOCRACY UNIVERSITY HEALTH SCIENCES JOURNAL
IDUHES
e-ISNN:2651-4575

IDUHeS, 2024; 7(2): 144-161
Doi: 10.52538/iduhes.1530457

Research Paper – Araştırma Makalesi

THE ROLE OF EXERCISE IN LYMPHEDEMA MANAGEMENT: A BIBLIOMETRIC ANALYSIS

LENFÖDEM YÖNETİMİNDE EGZERSİZİN ROLÜ: BİBLİYOMETRİK BİR ANALİZ

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Özet

Lenfödem yaşam boyu süren kronik bir sağlık sorunudur ve egzersiz yaklaşımları lenfödem tedavisinde altın standartlardan biri olarak kabul edilmektedir. Lenfödemde egzersiz yaklaşımları hakkında çok sayıda makale yayınlanmıştır. Bu çalışmada, lenfödemde egzersiz ile ilgili çalışmaların bibliyometrik bir analizini yapmayı amaçladık. Bu amaçla 24 Ekim 2023 tarihinde Scopus veri tabanında "lymphedema and exercise" anahtar kelimeleri kullanılarak bir arama yapıldı ve 869 doküman incelendi. Veriler ilgili arama motorundan indirildi. Bu veriler Vosviewer ve Biblioshiny paket programları kullanılarak analiz edildi. Yayın tarihleri 1957 ile 2023 arasında değişmektedir. Analiz sonuçlarına göre, makale yayınları açısından Amerika Birleşik Devletleri önde gelirken (n=979), uluslararası iş birliği açısından Avusturya liderdir (n=401). Lenfödem ve egzersiz anahtar kelimeleri kullanılarak en çok atıf alan yayın Campbell ve arkadaşlarının (2019) "Exercise Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable" başlıklı makalesi, 1101 atıfla 'Medicine & Science in Sports & Exercise' dergisinde yayımlanmıştır. "Lymphatic Research and Biology", 'Lymphology' ve 'Supportive Care in Cancer' bu alanda en çok atıf alan ilk üç dergidir. Özellikle Pennsylvania Üniversitesi, bu alana verimli araştırma çıktılarıyla katkıda bulunan en üretken kurum olarak öne çıkıyor. En üretken yazar 29 makale ile Kathryn H. Schmitz'dir. En sık kullanılan anahtar kelimeler arasında "lenfödem", "meme kanseri" ve "lenfödem, yaşam kalitesi" yer almaktadır. Bu çalışmanın bulguları sadece lenfödem ve egzersizle ilgilenen araştırmacılar ve uygulayıcılar için değil, aynı zamanda pratik uygulamalar ve gelecekteki potansiyel gelişmelerle ilgilenen herkes için değerlidir. Sonuç olarak, bu kapsamlı bilgi rehberi gelecekteki çalışmalar için önemli bir kaynak ve yol haritası görevi görebilir.

Anahtar Kelimeler: Bibliyometrik analiz, egzersiz, lenfödem, VOSviewer, fizyoterapi ve rehabilitasyon

Abstract

Lymphedema is a lifelong chronic health issue, and exercise approaches are considered one of the gold standards in lymphedema treatment. Numerous articles have been published on exercise approaches in lymphedema. In this study, we aimed to conduct a bibliometric analysis of studies related to exercise in lymphedema. For this purpose, a search was conducted in the Scopus database on October 24, 2023, using the keywords **"**lymphedema and exercise**"** and 869 documents were examined. Data were downloaded from the relevant search engine. These data were analyzed using the Vosviewer and Biblioshiny package programs. Publication dates ranged from 1957 to 2023. According to the analysis results, while the United States is the leading contributor in terms of article publications (n=979), Austria leads in terms of international collaboration (n=401). The most cited publication using the keywords lymphedema and exercise is the article by Campbell et al. (2019) titled **"**Exercise Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable,**"** published in the **"**Medicine & Science in Sports & Exercise**"** journal with 1101 citations. "Lymphatic Research and Biology", "Lymphology", and "Supportive Care in Cancer" are the top three journals with the most citations in this field. Particularly, the University of Pennsylvania stands out as the most prolific institution contributing to this area with productive research output. The most prolific author with 29 articles is Kathryn H. Schmitz. The most frequently used keywords include "lymphedema", "breast cancer", and "lymphedema, quality of life". The findings of this study are valuable not only for researchers and practitioners interested in lymphedema and exercise but also for anyone interested in practical applications and potential future developments. Ultimately, this comprehensive information guide could serve as an important resource and roadmap for future studies.

Keywords: Bibliometric analysis, exercise, lymphedema, VOSviewer, physiotherapy and rehabilitation

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1. INTRODUCTION

Lymphedema is defined as the abnormal accumulation of interstitial fluid in the subcutaneous tissues due to factors such as cancer, cancer treatment (surgery and/or radiotherapy), infection, inflammatory disorders, obesity, and hereditary syndromes (Ramachandran et al., 2021, pp.134-145). Lymphedema is generally classified into primary and secondary lymphedema. Primary lymphedema originates from congenital lymphatic vessel anomalies. Secondary lymphedema occurs as a result of obstruction or damage to the lymphatic system due to conditions such as filariasis, tumors, surgery, trauma, and radiation therapy. Secondary lymphedema is more prevalent than primary lymphedema today and is often associated with breast cancer treatment in most developed countries (Zhang et al., 2019,926237). Symptoms associated with lymphedema include pain, heaviness, tightness, decreased range of motion, impairment of gross and fine motor skills, disruption of daily functions, and decreased quality of life (Shaitelman et al., 2016, pp.55-81).

The current standard of treatment for lymphedema is Complex Decongestive Therapy (CDT), which consists of manual lymphatic drainage, bandaging, compression therapy, skin care, and exercise (Lasinski et al., 2004, pp.580-601). CDT, which is considered the gold standard in lymphedema treatment, is administered by a trained and certified lymphedema therapist. During CDT, exercises applied are referred to as remedial exercises. Remedial lymphedema exercises aim to increase muscle contraction in the lymphedematous area through repetitive movements (Özcan and Aras, 2016, pp.38-44). CDT is a two-phase, six-component treatment regimen. The initial intensive phase (edema reduction phase) (phase I) aims to reduce the size of the affected area and apply appropriate skin care. When maximum fluid volume reduction is achieved, the maintenance phase (phase II) begins, requiring lifelong self-care. Early diagnosis is crucial as it enables lymphedema to be treated most effectively, and when treatments are initiated early, complications are minimized (Christine and Janice, 2013, pp.28-40). Beyond traditional treatment, exercise, surgical interventions, and intermittent pneumatic compression (IPC) devices have evolved as potentially effective treatment methods (Christine and Janice, 2013, pp.28-40).

The inclusion of exercise as part of the current standard of treatment is a more recent development. Until the early 2000s, due to concerns that physical activities might lead to the development of new lymphedema or exacerbate existing lymphedema, individuals were advised to avoid ‘‘vigorous, repetitive, or excessive exercise’’ (Harris and Vertommen, 2000, pp.95-98). However, subsequent studies have debunked the notion that exercise could worsen lymphedema, reaching a consensus that resistance exercises can be beneficial not only for preserving the physical function of the affected extremity but also for maintaining and restoring a healthy body composition, thereby reducing metabolic risk (Hasenoehrl et al., 2020, pp.26-35; Keialani et al., 2016, pp.1907-1916).Among the physiological effects of exercise, it has been found to activate the pump mechanism in the musculoskeletal system, thereby increasing lymphatic and venous return. Upper body exercises and activities are said to influence the sympathetic nervous system and thus be beneficial in long-term intervention against lymphedema (Vergili, 2015, pp.102-107). A study reviewing randomized controlled trials assessing the effectiveness of exercise interventions in preventing, minimizing, or improving upper extremity dysfunction related to breast cancer treatment found that exercises implemented in the early postoperative period could lead to improvements in shoulder range of motion (McNeely et al., 2010, CD005211).It has been suggested that resistance exercises can

safely be performed to increase muscle strength only in situations where there is minimal risk of lymphedema onset or exacerbation. It is also mentioned that aerobic exercises can be used in conjunction with resistance exercises. Considering that exercises of excessive intensity can exacerbate edema, these exercises should be prepared by expert physiotherapists (Vergili, 2015, pp.102-107). Exercise is an important component in the prevention and control of cancer (Christine and Janice, 2013, pp.28-40). Women with breast cancer who exercise under the supervision of physiotherapists and receive adjuvant treatment have risks from exercise similar to those of healthy women without breast cancer (Düger et al., 2019, pp.71-78). Cancer survivors can benefit from exercise in various ways, including reducing fatigue, increasing strength and flexibility, and improving body image and quality of life. As the number of cancer survivors continues to increase, educating patients about appropriate exercise regimens for long-term health and cancer prevention is crucial (Christine and Janice, 2013, pp.28-40).

Bibliometric methods continue to evolve due to the accumulation of knowledge in the field. The term ‘‘bibliometrics’’ was first used by Pritchard in the 1920s. Impact factor and Hirsch index have been influential in the development and advancement of bibliometrics. It relies on analyzing data obtained from different and numerous sources using various statistical and mathematical methods. It is a method used for statistical analysis. It is carried out for two different reasons: performance analysis and scientific mapping. Performance analysis examines the research conducted by countries or institutions in the scientific field, while scientific mapping examines the updates and structure of the researched topic. Scientific mapping is a relatively new method among the methods. This method is a current approach used to make the most efficient use of data (Demir and Erigüç, 2018, pp.91-114).

As far as we know, this study is the first to conduct a bibliometric analysis of studies in the field of lymphedema and exercise. Reviewing studies related to exercise in lymphedema treatment is important for identifying research areas in this field and providing a valuable reference for future research. Through analysis, we hope that this study will provide a panorama of knowledge regarding exercise approaches in lymphedema, thus providing data to support the exploration of potential research gaps between countries and institutions.

1.1. Literature Review

Through author research, no bibliometric analysis was found in studies on lymphedema and exercise, and this study is the first to fill this gap in the literature. Bibliometric analysis, referred to as bibliometrics, is a method for quantitative analysis of bibliographic data that provides a systematic, data-driven approach to understanding the research environment. Bibliometric analysis is an effective tool for tracking research trends and developments (Demir et al., 2024, pp.290-314). For example, Kablan and Acar (2024, pp.157-166) conducted a bibliometric analysis study to provide perspectives on current treatment methods for peripheral lymphedema and conservative and surgical methods. Palma et al. (2023, e22499) conducted bibliometric analysis by including 979 publications from the Web of Science's Core Collection database between 2012 and 2022 to perform a detailed analysis of publications related to physical activity in breast cancer patients. Zhang et al. (2022, 926237) conducted a bibliometric analysis of 8569 articles published between 1900 and 2021 to analyze the characteristics of publications on lymphedema and topics such as the development process of lymphedema. Vakharia et al. (2017, pp.16-18) conducted a bibliometric analysis of 1144 articles published between 2007 and 2016 to characterize publications related to lymphedema associated with breast cancer. Ram (2015, pp.73-78) used the Scopus database for publications in the field of lymphatic filariasis. He included 13.598 articles published between 1973 and 2012 and conducted a bibliometric analysis of the subject.

A comprehensive review of academic studies in the field of exercise in lymphedema reveals two critical research gaps:

Bibliometric analysis has not been conducted for exercise in lymphedema stemming from lymphatic system disorders.

There is a need for a widely accepted model to evaluate studies related to lymphedema, a lymphatic system disorder.

This article presents a conceptual framework of studies related to exercise in lymphedema and identifies the most influential articles, authors, and countries in the field. The study can help researchers interested in exercise in lymphedema understand current and future research trends. Bibliometrix is an R package with a web-based interface, while VOSviewer is software designed for bibliometric analysis. This study is the first example of bibliometric research evaluating exercise in lymphedema. The main aim of this study is to address the following questions.

Who is the author with the most citations and publications related to exercise in lymphedema?

What is the journal with the most citations related to exercise in lymphedema, as well as the most cited article, university, and country?

What are the trending topics related to exercise in lymphedema?

Which countries collaborate most on research related to exercise in lymphedema?

This study, by revealing the conceptual richness of exercise studies in lymphedema, can assist researchers in the field of lymphatic system diseases to understand current and future research trends. Consequently, it can help them design more innovative and creative research endeavors.

2. MATERIALS AND METHODS

During bibliometric analysis, data preparation begins by selecting a preferred database such as Scopus, Web of Science (WoS), PubMed, etc., followed by downloading the data. Subsequently, certain filters are applied within the chosen database, including document type, language, publication type, publication year, etc. For this study, data were downloaded in .csv format on October 24, 2023, using inclusion and exclusion criteria for conducting bibliometric analysis of scientific articles. In the final step of bibliometric analysis, R Bibliometrix and VOSviewer software were utilized.

3. BIBLIOMETRIC ANALYSIS RESULTS N THE FIELD OF EXERCISE IN LYMPHEDEMA

4.1. Key statistical metrics of publications

This study provides a detailed overview of publications, assessing the annual growth rate of publications, average citation per publication, and the lifespan of a paper in the literature. Additionally, the journals and universities making the most significant contributions to the literature, in terms of citations received, were identified. Furthermore, the authors and countries with the most works cited in the literature were highlighted, along with their respective citations. A Sankey diagram was also used to identify the leading countries, keywords, and authors in relation to each other.

4.1.1. Descriptive statistics

A general evaluation of the publications related to lymphedema and exercise was conducted using Biblioshiny. The obtained information is presented in Figure 1.

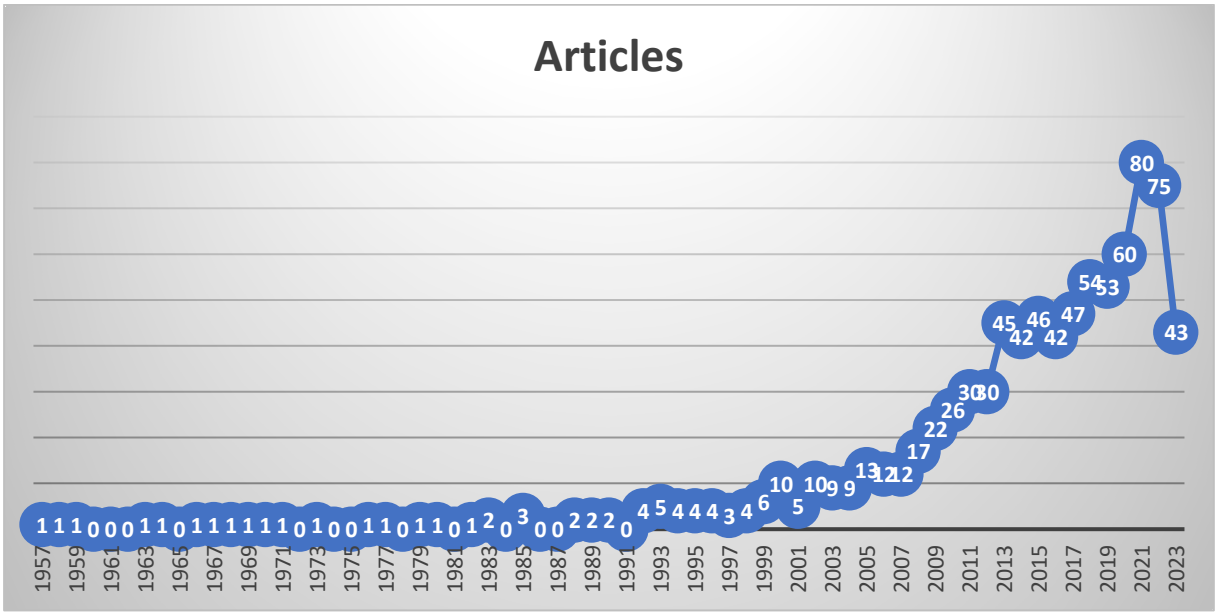
Figure 1: Main Information

From Scopus, a total of 854 articles related to the keywords ‘‘lymphedema’’ and ‘‘exercise’’ written between 1957 and 2023 were downloaded. These articles were authored by 3397 authors, out of which 79 authors had written articles individually. The average annual citation per article was 23.98. Additionally, the average age of the articles was 9.41 years.

4.1.2 Annual increase in publications

Figure 2 illustrates the increase in studies conducted in the fields of ‘‘lymphedema’’ and ‘‘exercise’’ over the years.

Figure 2: Annual Status of Publications

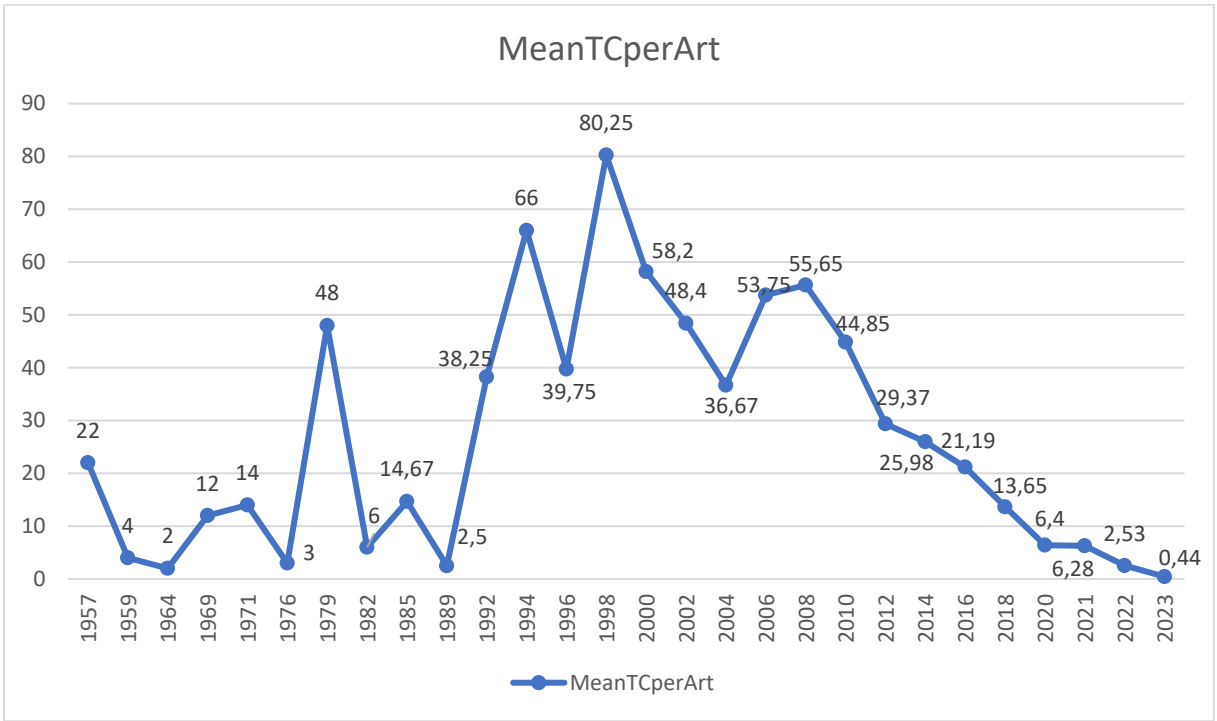


In 2023, 43 articles were published, while in 2022, there were 75, and in 2021, there were 80 articles.

4.1.3. Annual average citation status

The citations received by publications related to ‘‘lymphedema’’ and ‘‘exercise’’ over the years are presented in Figure 3.

Figure 3: Annual Average Citation Status of Articles

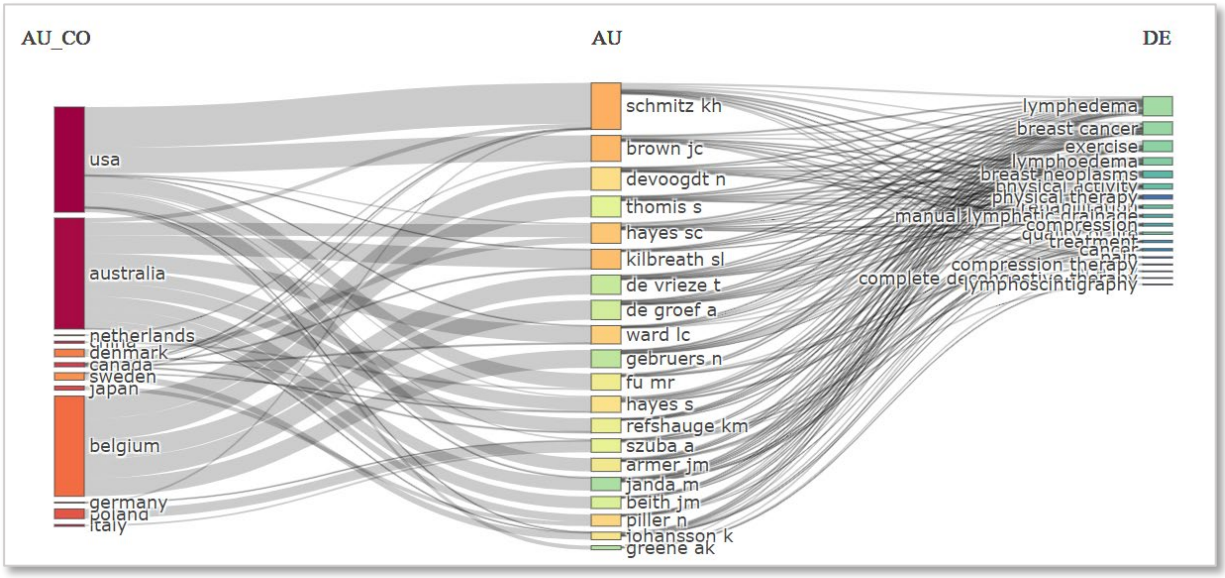


According to Figure 3, it can be observed that citations vary over time. In 2023, there were 0.44 citations, in 2022, 1.26 citations, in 2021, 2.09 citations, in 2020, 1.60 citations, in 2019, 6.22 citations, in 2018, 2.28 citations, in 2017, 2.23 citations, in 2016, 2.65 citations, in 2015, 2.25 citations, and in 2014, 2.60 citations annually.

4.1.4. Sankey diagram

The Sankey diagram, which associates three variables (country, author, keyword) desired to be related, is provided in Figure 4 by adjusting the options section in the biblioshiny program.

Figure 4: Sankey Diagram



AU_CO: countries, AU: authors, DE: keywords.

According to Figure 4, the size of the rectangles indicates the importance of the variables used in the literature. According to the Sankey diagram, the country that produces the most works in the field of lymphedema and exercise is the USA. The author named Schimtz is the one who contributes the most to the literature. Lastly, ‘‘lymphedema’’ is the most frequently used keyword.

4.1.5. Most important journals

The ranking of journals publishing articles in the ‘‘Lymphedema’’ and ‘‘Exercise’’ fields is provided in Table 1.

Table 1: Most Important Journals Publishing in the Field of Lymphedema and Exercise

Sources	Articles
LYMPHATIC RESEARCH AND BIOLOGY	43
LYMPHOLOGY	40
SUPPORTIVE CARE IN CANCER	30
JOURNAL OF LYMPHOEDEMA	26
BREAST CANCER RESEARCH AND TREATMENT	16
BRITISH JOURNAL OF COMMUNITY NURSING	16
CANCER	11
ACTA ONCOLOGICA	10
BMC CANCER	10
PHYSICAL THERAPY	10

In the field of lymphedema and exercise, the University of Pennsylvania ranks first with 64 articles, followed by the University of Sydney with 51 articles, and finally, Queensland University of Technology ranks third with 48 articles.

4.1.7. The most prolific authors

The Most Prolific Authors in the keywords ‘‘Lymphedema’’ and ‘‘Exercise’’ are presented in Table 3.

Table 3: Most Prolific Authors in the Field of Lymphedema and Exercise

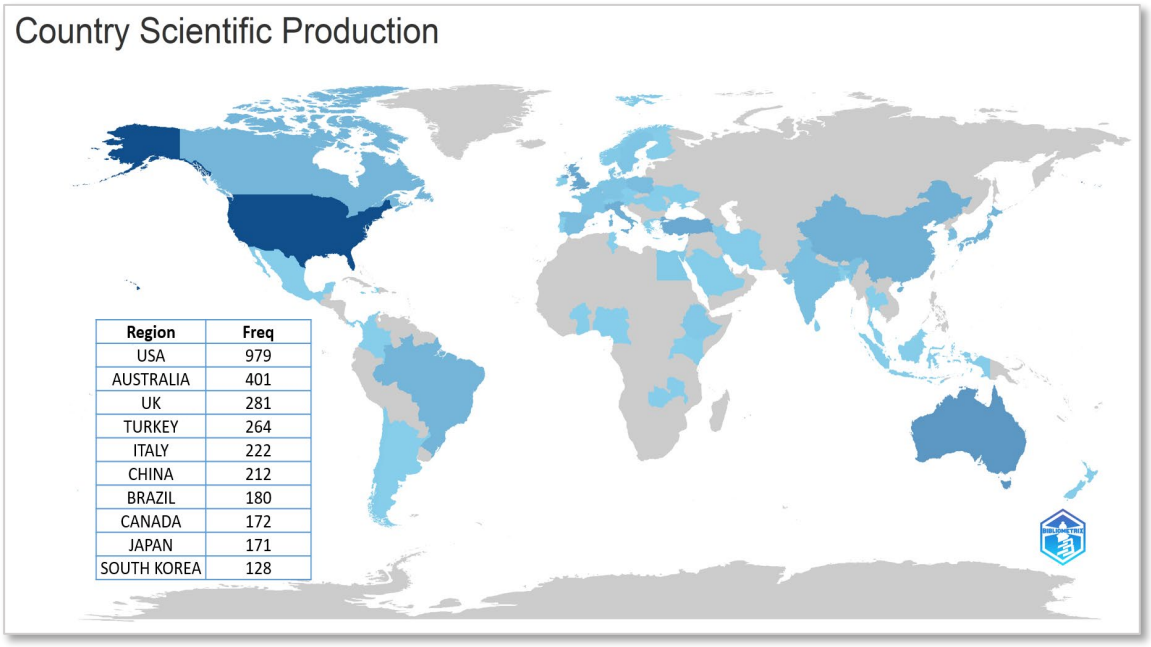
Authors	Articles
SCHMITZ KH	29
BROWN JC	16
KILBREATH SL	13
HAYES SC	12
WARD LC	11
PILLER N	10
DEVOOGDT N	9
HAYES S	9
JOHANSSON K	9
ARMER JM	8

In the field of lymphedema and exercise, Schmitz KH, ranks first with 29 articles, followed by Brown JC with 16 articles in second place, and Kilbreath SL with 13 articles in third place.

4.1.8. Most productive countries

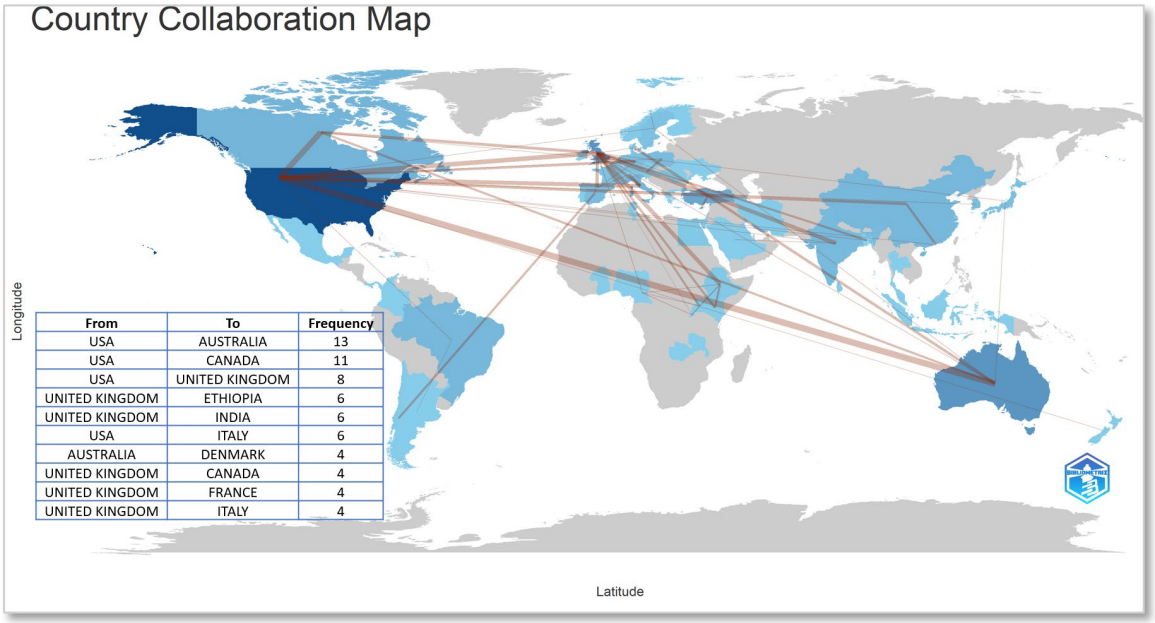
In this analysis, Figure 5 presents the most prolific countries, while Figure 6 depicts the relationship map among these countries.

Figure 5: Countries' Productivity



In the field of lymphedema and exercise, the most productive countries are as follows: the USA ranks first with 979 articles, followed by Austria with 401 articles in second place, and the United Kingdom in third place with 281 articles.

Figure 6: Network Map of Countries' Collaboration



Regarding collaboration, the USA has conducted 13 studies with Austria, 18 studies with Canada, 8 studies with the United Kingdom, and 6 studies with Italy. Furthermore, the United Kingdom, ranked second in collaboration, has conducted 6 studies with Ethiopia and 6 studies with India. Austria, ranked third, has collaborated with Denmark on 4 studies.

4.1.9. Most cited articles

The most important article is the one with the most total citations. Accordingly, the most important article is presented in Table 4.

Table 4: Most Cited Articles

Paper	DOI	Total Citations	Journal
CAMPBELL KL, et al., 2019, pp. 2375-2390	https://doi.org/10.1249/MSS.0000000000002116	1101	Med Sci Sports Exerc
COURNEYA KS, et al., 2007, pp. 4396-4404	https://doi.org/10.1200/JCO.2006.08.2024	801	J Clin Oncol
PETREK JA, et al., 2001, pp. 1368-1377	https://doi.org/10.1002/1097-0142(20010915)92:6<1368::aid-cncr1459>3.0.co;2-9	570	Cancer
PHELAN K, MCDERMİD HE, 2011, pp. 186–201	https://doi.org/10.1159/000334260	331	Mol Syndromol
SCHMITZ KH, et al., 2010, pp. 2699-2705	https://doi.org/10.1001/jama.2010.1837	313	JAMA
KO DSC, et al., 1998, pp. 452–458	https://doi.org/10.1001/archsurg.133.4.452	281	Archives of surgery
WEISSLEDER H, WEISSLEDER R,1988, pp. 729–735	https://doi.org/10.1148/radiology.167.3.3363131	262	Radiology
LACOMBA MT, et al., 2010, b5396	https://doi.org/10.1136/bmj.b5396	257	BMJ
MCKENZIE DC, KALDA AL, 2003, pp.463-466	https://doi.org/10.1200/JCO.2003.04.069	256	J Clin Oncol
AHMED RL, et al. 2006, pp. 2765-2772	https://doi.org/10.1200/JCO.2005.03.6749	241	J Clin Oncol

The article ‘‘Exercise Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable’’ is the most cited article with 1101 citations. Courneya et al. (2007, pp.4396-4404) conducted a study ‘‘The article "Effects of Aerobic and Resistance Exercise in Breast Cancer Patients Receiving Adjuvant Chemotherapy: A Multicenter Randomized Controlled Trial’’ was published in the journal ‘‘Journal of clinical oncology’’ and ranked second with 801 citations. In third place, the article ‘‘Lymphedema in a cohort of breast carcinoma survivors 20 years after diagnosis’’ by Petrek et al. (2001, pp. 1368-1377) was published in ‘‘ACS Journals’’ and received 570 citations.

The methods and results of the most cited articles are briefly summarized below;

Campbell et al. (2019, pp.2375-2390) was among the first reports to conclude that cancer survivors can participate in safe and adequate exercise training to improve physical fitness, regain physical functionality, improve quality of life, and reduce physical and mental fatigue caused by cancer.

Courneya et al. (2007, pp.4396-4404) conducted a randomized trial to evaluate the effect of resistance exercise and aerobic exercise on the adverse effects caused by breast cancer. These effects included fatigue, psychosocial functioning, physical fitness, body composition, chemotherapy completion rate and lymphedema. The study randomly assigned 242 breast cancer patients to a usual care group (n = 82), a supervised resistance exercise group (n = 82) or a supervised aerobic exercise group (n = 78). They found that exercise did not cause lymphedema or adverse events.

Schmitz et al. (2010, pp. 2699-2705) conducted a study of 154 people to compare the onset of lymphedema after a one-year weightlifting intervention with no exercise among survivors at risk of breast cancer-related lymphedema. They were enrolled in a 13-week program of weightlifting and supervised training and continued without exercise and supervision for the remaining 9 months. They found that in breast cancer patients at risk of

lymphedema, a slow progressive weightlifting program did not result in an increased incidence of lymphedema compared to no exercise.

Dicken et al. (1998, pp. 452-458) conducted a study of 299 participants to describe immediate and long-term volume reduction following complex decongestive physiotherapy for lymphedema. The first phase of complex decongestive physiotherapy included manual lymphatic drainage, multilayered non-elastic compression bandaging, therapeutic exercises and meticulous skin care. In the second phase, the treatment protocol focused on self-care through elastic arm or sock compression during the day, wrapping at night and continuous exercises. In conclusion, they found that complex decongestive therapy is a well-defined therapeutic intervention with more than 80% immediate and long-term success.

Lacomba et al. (2010, b5396) conducted a study with 116 participants to determine the effectiveness of early physiotherapy in reducing the risk of secondary lymphedema after breast cancer surgery. Manual lymph drainage technique and exercises for the use of the arm were performed. As a result, they found that early physiotherapy can be an effective intervention in preventing secondary lymphedema in women for at least one year after breast cancer surgery involving dissection of the axillary lymph nodes.

Mckenzie and Kalda (2003, pp.463-466) conducted a pilot study involving 14 participants to examine the effect of a progressive upper body exercise program on breast cancer treatment-related lymphedema. An 8-week progressive upper body exercise program consisting of resistance training and aerobic exercise was implemented and as a result, they found that participation in the upper body exercise program did not cause any change in arm circumference or arm volume in women who developed lymphedema after breast cancer and may have experienced an increase in their quality of life.

Ahmed et al. (2006, pp. 2765-2772) examined the effects of supervised upper and lower body weight training on the incidence and symptoms of lymphedema in 45 breast cancer survivors participating in a weight training study for breast cancer survivors. They found that the 6-month resistance exercise intervention did not increase the risk of lymphedema or exacerbate symptoms.

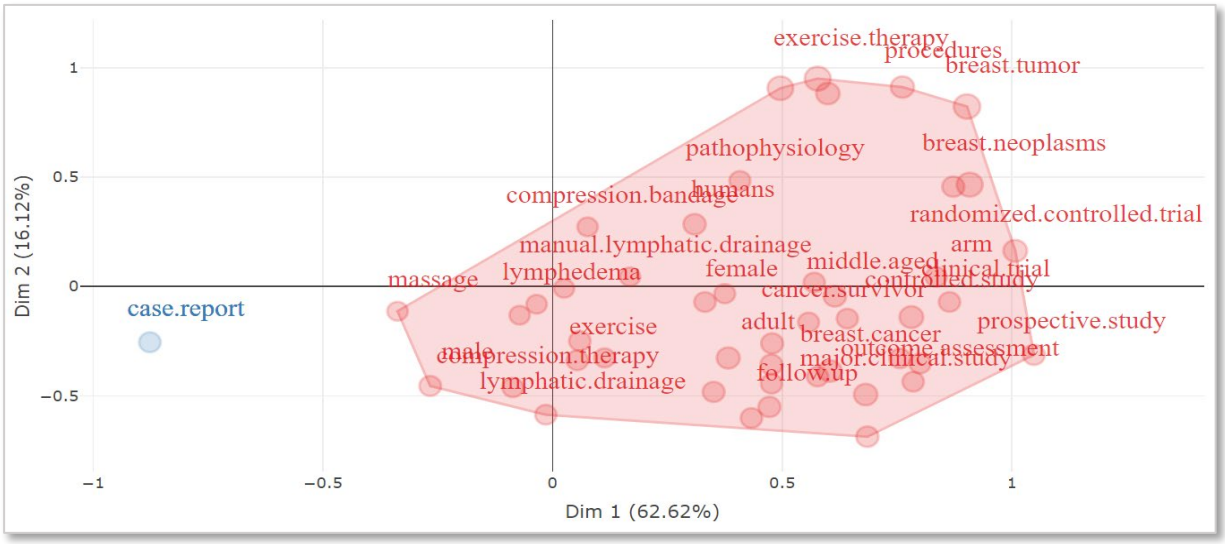
4.2. Analysis of scientific maps

Scientific mapping is the application of computational techniques as a whole to visualize, analyze and model various scientific and technical activities with scientific maps. (Demir et al., 2024, pp.290-314).

4.2.1. Conceptual structure map

This section presents the factor analysis, network map based on the author's keyword, trending topics, tree map and thematic map. Figure 7 shows the network map of the factor analysis.

Figure 7: Factor Analysis

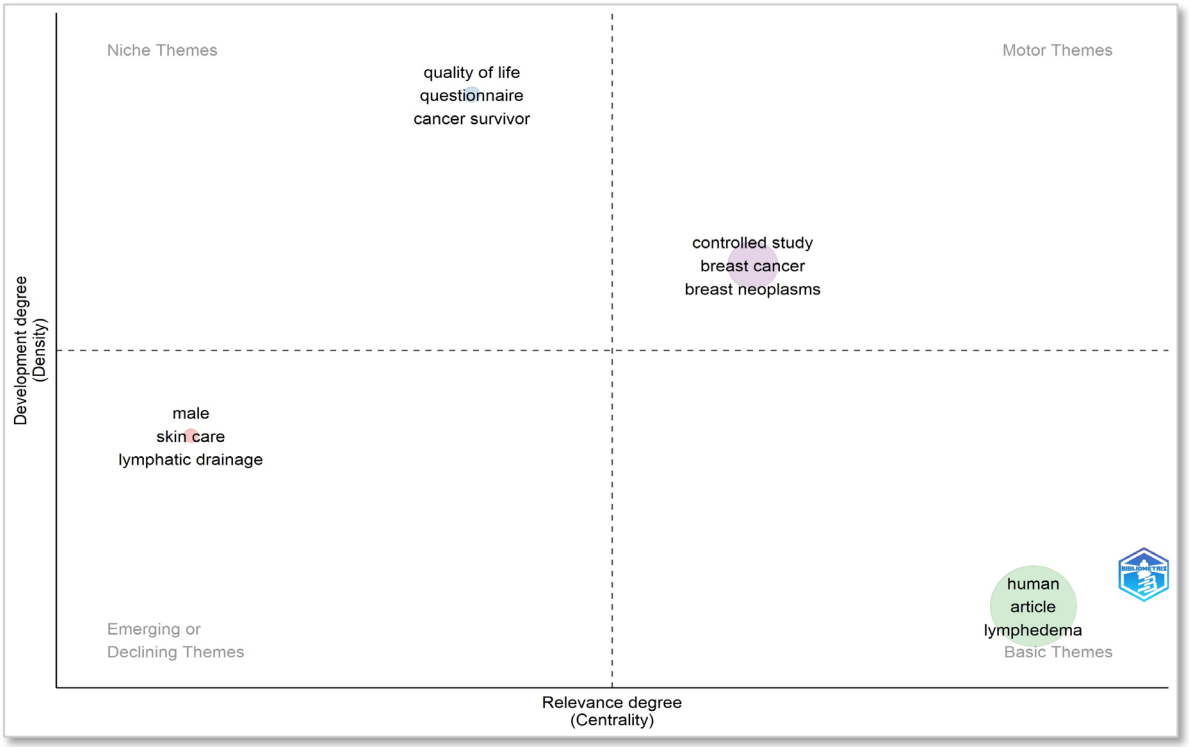


According to the factor analysis, the most important keywords used in the literature are clustered in the red cluster. ‘‘massage, exercise, therapy, manual lymphatic drainage, adult’’ are in this cluster. Then, ‘‘case report’’, which is a commonly used word in the literature, is in the blue cluster.

4.2.2. Thematic map

The thematic map of ‘‘lymphedema and exercise’’ articles represents the keywords used by the most important authors in the field. Figure 8 shows the thematic map for the words ‘‘lymphedema and exercise’’.

Figure 8: Thematic Map



In the literature, ‘‘human, article, lymphedema’’ is still used as the main theme. ‘‘controlled study, breast cancer, breast neoplasms’’ is used as the motor theme. Niche theme is ‘‘quality of life, questionnaire, cancer survivor’’. Emerging or Declibing theme is ‘‘male, skin care, lymphatic drainage’’.

4.2.3 Trending headlines

The most important words in the articles in which the words appeared in the literature between 1957 and 2023 are given in Table 5.

Table 5: Distribution of Keywords by Year

Item	Freq	Year_q1	Year_med	Year_q3
Lymphedema	1199	2010	2015	2020
Female	1042	2011	2016	2020
Human	797	2010	2016	2020
Adult	716	2010	2015	2020
Article	680	2010	2015	2020
Middle aged	567	2013	2017	2019
Humans	548	2012	2016	2020
Exercise	535	2012	2017	2021
Aged	493	2009	2014	2018
Quality of life	438	2013	2018	2021

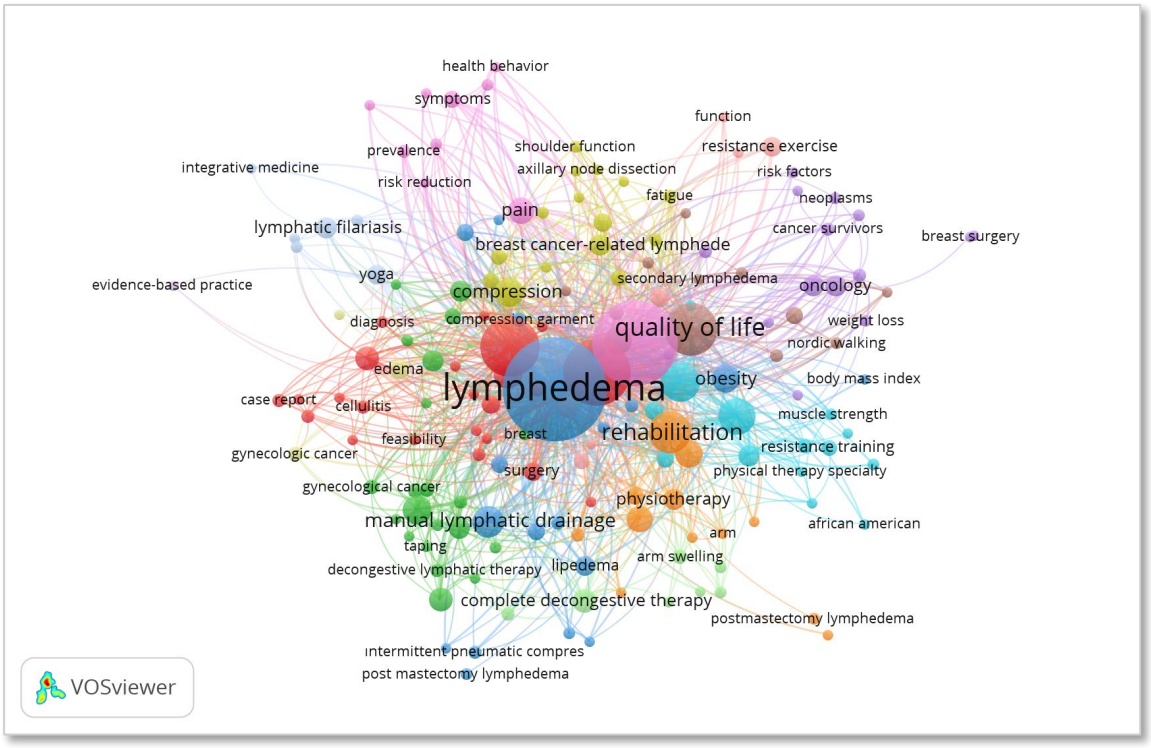
Freq:frequency ,year_q1: first quarter of the year, year_med: years, year_q3: 3rd quarter of the year.

The word ‘‘lymphedema’’ was used 1199 times in the literature. It was the most used word in the first quarter of 2010, the second quarter of 2015 and the third quarter of 2020. The word ‘‘female’’ was used 1042 times. It was the second most used word in the first quarter of 2011, the second quarter of 2016 and the third quarter of 2020. ‘‘human’’ used 797 times in the literature. It was the third most popular word in the first quarter of 2010, the second quarter of 2015, and the third quarter of 2020.

4.2.4 Keyword analysis

A keyword is defined as a word or group of words in an article. The most common form of the keywords in the articles is presented as a cluster and given in Figure 9.

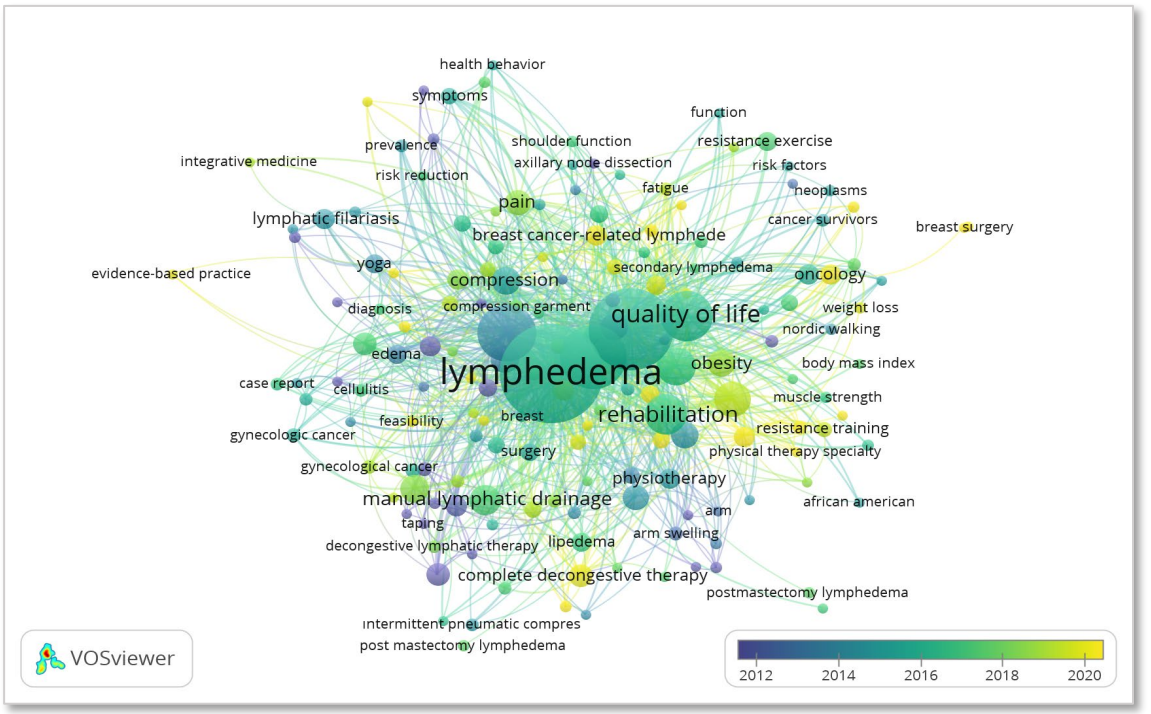
Figure 9: Keyword Analysis



The word ‘‘lymphedema’’ ranks first with 598 links and 263 citations, ‘‘breast cancer’’ ranks second with 452 links and 179 citations, and ‘‘exercise’’ ranks third with 339 links and 112 citations. ‘‘lymphedema, quality of life, rehabilitation’’ are the three most important keywords respectively.

The timeline (blue-green-yellow) of words in the 2012-2020 time range is presented in Figure 10.

Figure 10: Timeline of words



Previously used keywords such as ‘‘lymphedema, quailty of life, rehabilitation’’ are keywords that have been intensively studied in the 2012-2018 period. It can be said that keywords such as ‘‘physical therapy specialty, complete decongestive therapy, breast cancer-related lymphede’’ have been widely used in the literature recently.

4. DISCUSSION

Publications on lymphedema and exercise are constantly increasing. Scopus database was used to perform bibliometric analysis of these increasing studies. Initially, 854 journal articles in English were filtered and downloaded from the database. The annual growth rate of publications was 5.86%, the average age of articles was 9.41 years and the average citation per document was 23.98. 79 of the 3397 authors had published alone. In terms of authors’ collaboration in documents, international co-authorship is 14.64%.

According to the Sankey diagram, the most productive country is ‘‘America’’, the most important author is ‘‘Schmitz’’, and the most important word is ‘‘lymphedema’’.

This is the first bibliometric analysis to examine works on lymphedema and exercise to identify the most prolific authors, reference works, universities, countries and academic disciplines. As most of the articles are open access, a large number of authors emerge as the topic progresses, and contributions spread rapidly and widely. According to previous research, the United States, Austria and the United Kingdom are the most prolific authors in this field. The most productive document is the ‘‘Exercise Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable’’ is the most cited work. The journal with the highest number of publications is ‘‘Lymphatic Research and Biology’’. According to the research, among the organizations that conduct the most studies on the subject and the universities to which the authors are affiliated, ‘‘University of Pennsylvania’’ is the university that publishes the most. ‘‘Schmitz KH’’ is the most published author. The results of the study showed that different colors for keywords created different keyword clusters. ‘‘lymphedema, breast cancer, exercise’’ were defined as keywords. In this study, scientific maps were used to provide a detailed overview of the main trends and results in research linked to ‘‘lymphedema and exercise’’, including the main themes, trending topics and conceptual structures (factor analysis) that classify how an author’s work is influenced. As a result of the factor analysis, the most important keywords used in the literature were grouped in the red cluster ‘‘massage, exercise, therapy, manual lymphatic drainage, adult’’. Then, ‘‘case report’’, which is a commonly used word in the literature, is in the blue cluster. As a result of the analysis made to determine the themes in which keywords are used in the literature, ‘‘human, article, lymphedema’’ is still used as the main theme in the literature. ‘‘controlled study, breast cancer, breast neoplasms’’ is used as the motor theme. Niche theme is ‘‘quality of life, questionnaire, cancer survivor’’. Emerging or Declibing theme is ‘‘male, skin care, lymphatic drainage’’. The word ‘‘lymphedema’’ was used 1199 times in the literature. It is the most used word in the first quarter of 2010, the second quarter of 2015 and the third quarter of 2020. This study focused on publications indexed in the Scopus database and to our knowledge is the first bibliometric analysis of the literature on lymphedema and exercise published between 1957 and 2023.

By summarizing in depth the studies on lymphedema and exercise, we hope that our findings will lead to additional research directions and perspectives in the rapidly expanding field of lymphatic system diseases. Administrative implications for future studies can be listed as follows:

This research provides valuable data regarding the most influential sources, most influential authors, most influential links, and most influential countries and most influential studies in the available literature on lymphedema and exercise assessment. Researchers and practitioners have the option to choose which articles to reference, which articles are most relevant, and which articles have the most impact on lymphedema and exercise.

This bibliometric review of studies on lymphedema and exercise in physiotherapy and rehabilitation can help to- the findings of the study reflect the state of research on lymphedema and exercise. Furthermore, as a reference point, this study provides researchers with a comprehensive understanding of lymphedema and exercise.

By utilizing citation analysis, researchers can identify the different research streams or areas that make up their intellectual structure, allowing them to identify themes and knowledge.

Depending on the research area, it is possible to identify gaps in the literature and potential research directions. provide a comprehensive overview of past and current research and identify future research directions for lymphedema and exercise.

As a result, it provides important up-to-date information for academics and health professionals to apply in their future work in the field of lymphedema and exercise. While the Scopus database was the main focus of this study, other sources such as Dimensions, Web of Science, Cochrane Library and Pubmed could also be utilized. A potential next step is to design and build graphical tools that present more data and cover more domains.

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