Review Article

Bibliometric Profile and Density Visualizing Analysis of Yoga Intervention in Type 2 Diabetes: A 44 - Year Study on Global Scientific Research Output from 1975 to 2019

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Abstract

The aim of the paper is to provide an in-depth evaluation of the research output of yoga intervention on type 2 diabetes mellitus from 1975 to 2019 using large-scale data analysis, bibliometric indicators, and density equalizing mapping. Data related to yoga-diabetic research, as search descriptors were retrieved using the Scopus database. The most common bibliometric indicators were annual research output, total citations, productive countries and leading authors, journals and institutions, and frequently cited articles. The number of global research articles retrieved for yoga-diabetic research over the study period 1975–2019 was 411. The growth rate of global publications in 2015–2019 is four times as high as in 1975–2003. The total number of citations for the retrieved articles was 7189, and the average number of citations per article was 23.82. Of these journals, the Journal of Alternative and Complementary Medicine has published the highest number of papers, which accounts for 2.9% of total publications. This study showed a wide variety of journals in which yoga-diabetic articles are published; these bibliometric indicators provide useful information on performance assessment of productivity and quality of research output. Therefore, this study provides a helpful reference for endocrinologists, yoga therapists, policy decision-makers, and diabetes researchers.

Keywords: *Bibliometric profiling, intervention, type 2 diabetes, yoga*

Introduction

Yoga and its practices

Yoga originated in India around 5000 B. C. E and is a practice that integrates physical, mental, and spiritual practices. The practice includes asanas (specific postures), pranayama (breathing practices), dhyana (meditation), mantras (chants), and sutras (wisdom teachings) to inspire health and relaxation.[1,2] Yoga intends to initiate the body for meditation and to improve emotional well-being. The practice comprises two significant prototypes including Raja (royal or classical) Yoga and Hatha Yoga (Yoga of activity and styles). Besides, the third form, mantra yoga, was popularised by Maharishi Mahesh Yogi, the founder of Transcendental Meditation, where more importance is given to the use of specific sounds or chants to achieve mental and spiritual transformation.[3,4]

Yoga styles

Classical Yoga philosophy and practice comprise many diverse styles; some of them are traditional practices such as Ashtanga, Kundalini, and Vinyasa. The styles were developed by renowned yoga gurus and spiritual leaders of India.[5,6] The five major styles include (1) Viniyoga style (individualized style of postural Yoga developed by Tirumalai Krishnamacharya and taught by his son T. K. V. Desikachar); (2) Integral yoga style (comprises six branches: Hatha, Raja, Bhakti, Karma, Jnana, and Japa Yoga by Sri Swami Satchidananda Saraswati); Iyengar style (developed by B. K. S. Iyengar); (3) Sivananda Yoga (based on four paths (Karma Yoga, Bhakti Yoga, Raja Yoga, and Jnana Yoga) and 5 points of Yoga (Proper Exercise, Proper Breathing, Proper Relaxation, Proper Diet and Positive Thinking and Meditation) founded by Swami Vishnudevananda

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based on the teachings of his beloved guru Swami Sivananda); (4) Kripalu (developed by Amrit Desai) and (5) Bikram yoga (developed by Bikram Choudhury).

Yoga participation practice worldwide

Global yoga participation has increased, with over 30 million people practising Yoga for health benefits daily since 2005.[7] However, this number might still undervalue the actual frequency of yoga practice.[8] Yoga Alliance and Yoga Journal demonstrated that the number of Americans engaging in Yoga has increased in the last 4 years by over 50% to over 36 million as of 2016, from 20.4 million in 2012. Furthermore, nine out of 10 Americans have heard of Yoga, one in three Americans has tried Yoga at least once, and more than 15% of Americans have performed Yoga in the past 6 months.[9] Yoga is considered a safe and effective approach, in health and illness, for people of all ages that are actively promoted by the National Health Service in the United Kingdom (UK).[10] Yoga participation in Australia is considered as preferred cardio, strength, and flexibility exercise, with 2.18 million Australians participating in Yoga in the year to December 2017.[11]

Therapeutic applications of Yoga

The interpretations of the practice and philosophy of Yoga diverge with several applications of spiritual, cultural, and therapeutic knowledge because of a drastic increase in the number of yoga practitioners and yoga schools in western countries.[12] Therapeutic applications of Yoga have been validated in a wide variety of medical conditions such as psychopathological, cardiovascular, respiratory, and metabolic diseases. National Center for Complementary and Integrative Health (The National Institutes of Health [NIH]) reported that Yoga is a safe and effective intervention to increase strength, flexibility, and balance, and the practice is considered as a treatment for many medical conditions, including high blood pressure, heart diseases, diabetes, aches and pains, depression, stress, and asthma.[13] Proper functioning of the hypothalamic-pituitary-adrenal axis regulates many bodily functions, including metabolism, the immune system, healthy growth and development, thyroid function, and reproduction.[14] However, the research has not clearly articulated the underlying mechanisms concerning neurobiological and endocrinological changes during yoga intervention in type 2 diabetes mellitus (T2DM) patients.[15] In summary, the holistic application of Yoga as a complimentary and adjuvant therapy in clinical practice may lead to health benefits beyond traditional treatment alone.[16]

Yoga and type 2 diabetes mellitus

The number of people with diabetes in the world was 387 million in 2014 and is expected to increase to 592 million by 2035 for all forms of diabetes.[17] Many previous reports showed that Yoga could reduce fasting blood glucose and glycosylated hemoglobin A1c as well as improve the lipid levels and quality of life of T2DM patients.[18-25] Systematic reviews describing the efficacy of Yoga for Type II diabetes have shown promising results of this intervention on blood glucose levels, insulin sensitivity, oxidative stress, lipid profile, anthropometric measures, pulmonary measures, nerve conduction, and quality of life.[5,26]

Bibliometric profile of yoga studies

A bibliometric profile of any specific medical condition informs practitioners, therapists, and researchers to acquire and also consolidate their knowledge about current research trends, clarifies the contribution of the country or institution in a given topic, and sheds more light on co-authorship and collaboration.[6] Furthermore, bibliometric indicators such as citations and Hirsch-(h) index can be used to inform university ranking, application funding, and productivity and citation impact of the publications of a scientist or scholar. All this information also helps to dictate the scientific prestige among the scientific community. A previously published bibliometric study reported the growth of the field of yoga research around the world in the last decade.[27]

Rationale of this study

A few bibliometric studies on global yoga research have been published in various scientific disciplines. These studies explored yoga-related publications on PubMed from January 1950 to December 2012 in the Western health-care context,[28] yoga therapy research in clinical populations to highlight the prevalence of yoga studies to alleviate disease-related symptoms[16] and randomized yoga trials that have investigated the therapeutic value of yoga interventions.[8] Yoga's therapeutic application in the field of the management of T2DM has been explored in a growing number of studies and clinical trials to date; however, synthesis of evidence as bibliometric profile analysis in the management of T2DM is limited. Hence, the purpose of the present study is to provide a comprehensive picture of available research evidence in the field of the management of T2DM through a bibliometric analysis. The analysis of bibliometric characteristics of scientific yoga research in the management of T2DM could aid practitioners, therapists, and researchers better understand the research field in-depth and learn more about current research trends, the impact of their research, and scientific collaboration. Therefore, this study is aimed to analyze the global research publications on yoga interventions on T2DM using a bibliographic analysis of articles indexed in Scopus.

Specific objectives of the study

The main objective of the study was to analyze global scientific research in yoga studies on T2DM (1975–2019), as reflected in various publications during this time. The study was designed to fulfill the following objectives:

- To study the research output and growth of diabetic yoga research such as types of documents, and

publications in various languages, as well as the number of publications and citations
- To assess the origin and study patterns of publications, including productive countries in the field of yoga interventions to manage T2DM patients
- To identify the publication productivity of leading authors and institutions who have been driving this research
- To understand the publication impact of frequently cited articles, journals and funding for the future development of this therapeutic field.

Methods

Data sources

The data in the study were sourced using the Scopus database. Scopus is produced by Elsevier and offers many characteristics to facilitate bibliometric analysis on any specific medical condition.[6] Therefore, Scopus was used to search for all published articles related to T2DM. Scopus offers many advantages compared to other databases and search engines, covering >20,000 journals that have 100% Medline coverage. Besides, it is considered a better search engine than other databases because it offers 20% more coverage than Web of Science and produces more results of consistent accuracy.[29] The Scopus database is most commonly used to source relevant articles for health professionals and academics in Australia and the Western hemisphere, primarily because of its subject focus, abundance of material, and free-access to medical abstracts in the English language. Therefore there is no necessity to require permission from Scopus, as we retrieved from published literature. The Human Research Ethics Committee approval was not required as the extracted data for this analysis were publicly available and are not related to specific patient's data and profiles. The study period for this bibliometric analysis was established from its inception through January 31, 2019.

Key terms

All subject types, including Medicine, Genetics and Molecular Biology, Pharmacology, Toxicology and Pharmaceutics, Health Professions, and Nursing, were chosen using the Scopus database. All documents were searched for the following keywords or phrases either in their title or abstract: (TITLE ["Yoga"] AND TITLE [Humans] OR TITLE ["Diabetes Mellitus"] OR TITLE ["Non-Insulin Dependent Diabetes Mellitus"] OR TITLE ["Alternative Medicine"] OR TITLE ["Female"] OR TITLE ["Male"] OR TITLE ["Exercise"] were retrieved and analyzed. These search strings were used in combination and have been selected based on the broad definition of T2DM/diabetes and any alternative names available for diabetes. Retrieved data and documents were manually checked for the validity of the selection criteria, and documents that were out of scope were removed. Two authors performed manual validation using the predefined inclusion and exclusion criteria.

Selection criteria

Inclusion criteria

1. T2DM or diabetes papers that focused on yoga intervention or exercise or alternative medicine or lifestyle changes to improve the quality of health
2. The definition also comprises studies that are designed to either improving symptoms through performing yoga asanas, pranayama, and meditation in addition to other traditional yoga practices and philosophies
3. Documents in all languages were included
4. Documents with clinical symptoms related to clinical diagnoses of T2DM were considered.

Exclusion criteria

1. Documents that were categorized as abstracts, dissertation reports, case reports, case series, or un-defined type of documents were excluded

The collected data were transferred to the MS Office Excel sheet that permitted us to manage the information contained in the records and to retrieve bibliometric indicators.

Bibliometric indicators

The core bibliometric indicators presented in this study were categorized into four categories:

a. *Overview of the research output and growth of diabetic yoga research*: This includes types of the document, the language of the document, year of the published document, and total citation
b. *Origin and study patterns of publications: This* included productive countries and subject area of the publications
c. *Publication productivity*: The leading authors and institutions in this field
d. *Quality of Publication output: This* included the impact of frequently cited articles and journals (Hirsch index [h-index], citation per article, impact factor, Cite Score, SCImago Journal Rank [SJR indicator] and Source-Normalized Impact per Paper [SNIP] of journals).

The indicators had been utilized in previously published bibliometric studies.[6,8,16,30,31]

Analysis

Productivity indicators

The productivity indicators such as annual publications, growth rate per specific period (in 5 years), the journal, and subject area distribution were estimated.[32] The growth rate per specific period was estimated as a difference in the number of articles published during that period divided by the number of articles published at the start of the period) ×100.[6]

Scopus metrics for journal productivity

The Scopus Journal Analyser uses the following metrics for Scientific Journal Ranking: CiteScore, SCImago Journal Rank (SJR indicator), and SNIP of journals. These metrics can be used to measure the prestige of a particular journal within the database. Besides, Scopus also analyses the scholarly output and impact of authors, institutions, and countries (Hirsch index). CiteScore is estimated as the number of all citations documented in Scopus in one whole year to content published in the past 3 years, divided by the number of items published in the journal. SCImago Journal Rank (SJR indicator) is defined as a measure of scientific influence of scholarly journals that accounts for both the number of citations acknowledged by a journal and the importance of the journals that cited these papers. Source-SNIP refers to a corrective metric to estimate citation potential (contextual citation impact) in different scientific fields. The Hirsch index measures both journal productivity and scientific impact; this index was used to assess the quantity and quality of publications per country or per institution or per author.[33]

Density visualizing mapping

VOS viewer software is a bibliometric software that displays (most frequent search terms) as bubble maps.[31] This software was used to prepare bibliometric maps and visualization methods.[34] Density visualization maps were generated to display the most frequently encountered search terms in title and abstract of retrieved articles using the VOS viewer and thresholds of minimally ten fractionally counted articles for each term. The technique creates maps that appear as either as density or network visualization maps and map visualizes terms that appeared in at least 5 of the 100 articles.

Results

Type of documents and languages of yoga and diabetes publications

Results of the search query in the Scopus search engine yielded 411 journal articles during the specified time. Of this number, 55.52% were original research articles, whereas the remaining documents were review, editorials, note, conference paper, letter to the Editor, book chapter, short surveys, and erratum [Table 1]. The primary language of recovered articles was English (405; 98.54%). Other languages in our analysis were German, Hebrew, Japanese, Portuguese, and Spanish. Table 2 shows the most commonly encountered languages.

Most frequent search terms

In mapping search terms frequency among the 6496 terms, 31 terms met the threshold of 50 times as a minimum number of occurrences. Then, 63 terms were selected as relevant terms based on the calculated relevance references score. Figure 1 displays the density visualization map of

Table 1: Type of documents of yoga and diabetes publications (1975-2019)

Type of documents	Frequency (%)
Article	236 (57.52)
Review	109 (26.46)
Editorial	24 (5.83)
Note	10 (2.43)
Conference paper	8 (1.94)
Letter	8 (1.94)
Book chapter	6 (1.46)
Short survey	6 (1.46)
Erratum	3 (0.73)
Book	1 (0.24)

Table 2: The most commonly encountered languages of the retrieved articles (1975- 2019)

Rank	Language	Total number of documents (%)
1	English	405 (98.54)
2	German	2 (0.49)
3	Hebrew	1 (0.24)
4	Japanese	1 (0.24)
5	Portuguese	1 (0.24)
6	Spanish	1 (0.24)

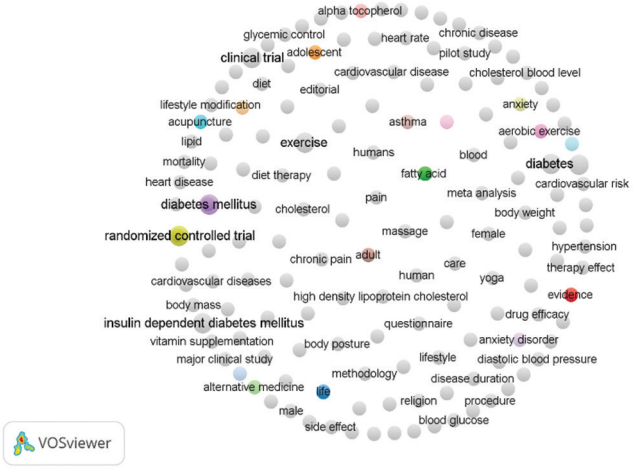

Figure 1: Term map using words from titles and abstracts of the most-cited yoga and diabetes articles

the most frequently encountered terms in retrieved articles on Yoga and diabetes. For example, the "diabetes" term was more commonly encountered than the "yoga" term in retrieved articles. Based on the map, the following terms "clinical trials = 6909 occurrences," "diabetes mellitus = 5182" and "diabetes = 4395" had the highest frequency and were represented in three clusters in the density visualization map [Figure 1].

Search terms or keywords from titles and abstracts were phrased, analyzed, and visualized by VOSviewer. Each bubble represents a term or phrase. The bubble size indicates its frequency of occurrence. The bubble color

indicates the averaged citation counts received by articles containing the term or phrase. Lower left and right corners contain many search terms and phrases that express Yoga and diabetes; articles containing them had more citations than the average, as indicated by the red, blue, yellow, and green bubbles.

Publications time point

Approximately one-third (83; 8.5%) of the retrieved articles were published in the first half of the study period (<2004 refers the period from inception[1975] to 2003) while two-thirds (81; 19.7%) were published in the second half of the study period (2004–2009). The growth rate of publications from 2010 to 2014 was 34%, and from 2015 to 2019 was 37%. Figure 2 shows the number of retrieved articles per year (Open Access, Close Access, and Total) as well as the total number of citations. Articles published in 2017 attracted the highest number of citations and number of publications.

Top publishing countries

Table 3 illustrates the top 10 productive publishing countries in the field of research. A total of 61 countries contributed to the advancement of yoga-diabetic research [Figure 3]. India ranked first, United States ranked second on the number of publications. Based on our analysis, India's global publication share was 35.52% during the study period, the USA's publication share was 32.36% of global output. UK ranked third (7.3% share), Canada ranked fourth (3.89% share), and Australia ranked fifth with a 3.65% share.

The total number of citations for the retrieved articles was 7189, and the average number of citations per article was 23.82. Publications from the USA attracted the highest share of citations (2968), followed by publications from India (1608) and the UK (1107). However, publications from Germany attracted the highest number of citations per article (43.47) followed by publication from Cuba (39.25) and UK (36.9). When the h-index was used to assess the country's impact on yoga and diabetes publications, the USA ranked first (29), followed by India (23) and the UK (12).

Most productive and publishing authors

Table 4 shows the top 10 most productive authors in yoga and diabetes research. Three authors Innes, Singh, and Tandon, have contributed to nine publications within 411 articles. Figure 4 shows the visualization density map of the most productive publishing authors. Scopus ranks authors according to their productivity regardless of their position in the manuscript. Three authors listed in the top 10 most productive authors are from New Delhi, India, and affiliated with All India Institute of Medical Sciences, University College of Medical Sciences Department of Physiology, and University College of Medical Sciences Department of Endocrinology. Of the most productive authors, eight were from India, one from the USA and

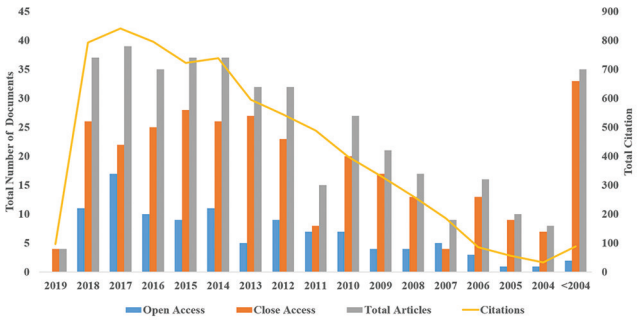

Figure 2: Yoga-diabetic research publication time trend with total number of citations

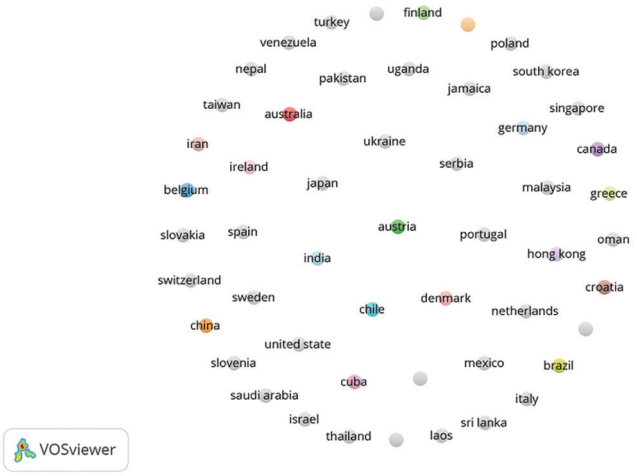

Figure 3: Visualisation density map of the most productive publishing countries

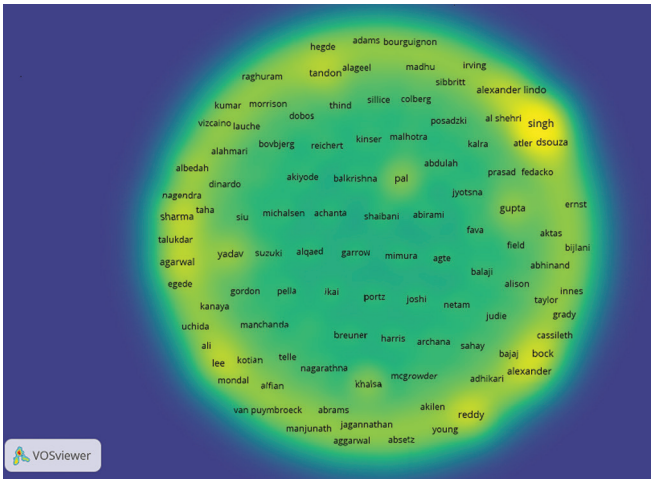

Figure 4: Visualisation density map of the most productive publishing authors

one from Germany. The highest rate of citations per article corresponds to Bijlani, followed by both Singh and Tandon.

Publications by subject areas

The manuscripts were published in journals under different subject areas of yoga-diabetic research from 1975 to 2019.

Table 3: Top 10 productive countries in the number of yoga-diabetic publications (1975- 2019)

Rank	Country	Total number of articles (%)	Total citation (%)	h index	Citation per article
1	India	146 (35.52)	1608 (22.78)	23	11.01
2	United States	133 (32.36)	2968 (42.05)	29	22.32
3	United Kingdom	30 (7.30)	1107 (15.68)	12	36.9
4	Canada	16 (3.89)	349 (4.94)	6	21.81
5	Australia	15 (3.65)	652 (9.24)	7	43.47
6	Germany	8 (1.95)	280 (3.97)	4	35
7	South Korea	5 (1.22)	31 (0.44)	2	6.2
8	China	4 (0.97)	16 (0.23)	2	4
9	Cuba	4 (0.97)	157 (2.22)	3	39.25
10	Italy	4 (0.97)	73 (1.03)	3	18.25

Table 4: Top 10 productive authors in some yoga and diabetes publications (1975- 2019)

Rank	Author	Number of articles (%)	Total citations (%)	h index	Citation per article	Affiliations and country
1	Singh, S	9 (2.18)	279 (3.95)	8	31	Department of Physiology, University College of Medical Sciences, New Delhi, India
2	Tandon, OP	9 (2.18)	279 (3.95)	8	31	Department of Physiology, Guru Teg Bahadur Hospital, India
3	Innes, KE	9 (2.18)	180 (2.54)	6	20	Department of Epidemiology, West Virginia University, Morgantown, United States
4	Nagarathna, R	8 (1.94)	180 (2.55)	6	22.5	Swami Vivekananda Yoga Anusandhana Samsthana, India
5	Nagendra, HR	7 (1.70)	61 (0.86)	4	8.71	Department of Yoga and Life Sciences, Swami Vivekananda Yoga University (S-VYASA), Bengaluru, India
6	Madhu, SV	6 (1.45)	223 (3.16)	6	37.16	Department of Endocrinology, University College of Medical Sciences, New Delhi, India
7	Malhotra, V	6 (1.45)	222 (3.14)	6	37	Department of Physiology, Santosh University, Ghaziabad, India
8	Adhikari, P	5 (1.21)	83 (1.18)	3	16.6	Department of Medicine, Yenepoya University, Mangalore, India
9	Bijlani, RL	5 (1.21)	268 (3.80)	4	53.6	Department of Physiology, All India Institute of Medical Sciences, New Delhi, India
10	Cramer, H	5 (1.21)	118 (1.67)	3	23.6	Universität Duisburg-Essen, Essen, Germany

Figure 5 shows the most productive subject areas that included 30 or more manuscripts. The total subject areas in 411 papers were 591, and the vast number of areas in those publications were Medicine (58.2%), followed by Biochemistry, Genetics and Molecular Biology (13.7%), Pharmacology, Toxicology and Pharmaceutics (6.9%), Health Professionals (6.6%) and Nursing (5.6%)

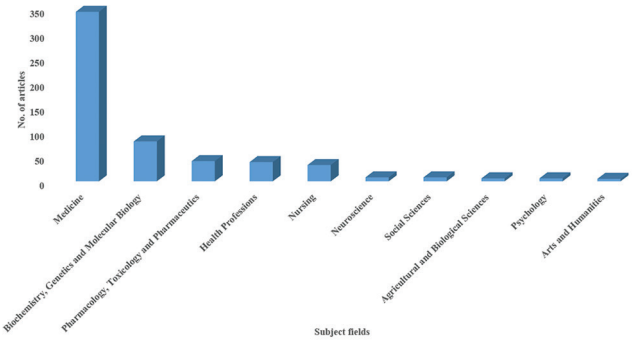

Figure 5: Represents the most productive subject area

Most frequently cited articles (hot papers)

The most frequently cited articles with more than 100 citations are depicted in Table 5. The article which received the highest citation was "Evidence-based guidelines for cardiovascular disease prevention in women: 2007 Update" authored by Mosca *et al*. and published in 2007 in Circulation Journal.[35] The second-highest number of citations was published in Thorax in 2008 and received 336 citations. The number of papers without citations was 121, which represents 29.44% of the total.

Productivity of institutions

Table 6 shows the most productive institutions among 370 institutions in yoga-diabetic research: All India Institute of Medical Sciences, New Delhi (3.89%), followed by the University of College of Medical Sciences (2.19%), and Guru Teg Bahadur Hospital (1.7%). Fifty per cent of the top 10 most productive institutions are based in India, whereas the rest are in the USA and Germany. The University College of Medical Sciences is affiliated with Guru Teg Bahadur Hospital, and most institutions are government and public sector, nonprofit, corporate teaching hospitals, and yoga centers.

Table 5: Topmost frequently cited ten articles (hot papers) on yoga-diabetic research

n	Authors	Title	Year	Journal	Number of citations	Document type
1	Mosca *et al*. 2007[35]	Evidence-Based Guidelines for Cardiovascular Disease Prevention in Women: 2007 Update	2007	*Circulation*	543	Review
2	Douglas *et al*. 2008[36]	British Guideline on the Management of Asthma: A national Clinical Guideline	2008	*Thorax*	336	Review
3	O'Donovan *et al*. 2010[37]	The ABC of Physical Activity for Health: A Consensus Statement from the British Association of Sport and Exercise Sciences	2010	*Journal of Sports Sciences*	314	Article
4	O'Connor *et al*. 2003[38]	Nonsurgical Treatment (Other Than Steroid Injection) for Carpal Tunnel Syndrome	2003	*Cochrane Database of Systematic Reviews*	226	Review
5	Obstetricians and Gynecol (2015)[39]	Physical Activity and Exercise During Pregnancy and the Postpartum Period-Committee Opinion no. 650	2015	*Obstetrics and Gynecology*	157	Review
6	Bijlani *et al*. 2005[40]	A Brief but Comprehensive Lifestyle Education Program Based on Yoga Reduces Risk Factors for Cardiovascular Disease and Diabetes Mellitus	2005	*Journal of Alternative and Complementary Medicine*	128	Article
7	Khalsa 2007[27]	Yoga as a Therapeutic Intervention: A Bibliometric Analysis Of published Research Studies	2004	*Indian Journal of Physiology and Pharmacology*	123	Review
8	Gordon *et al*. 2008[19]	Effect of Exercise Therapy on Lipid Profile and Oxidative Stress Indicators in Patients with type 2 Diabetes	2008	*BMC Complementary and Alternative Medicine*	119	Article
9	Innes and Vincent 2007[41]	The Influence of Yoga-Based Programs on Risk Profiles in Adults with Type 2 Diabetes Mellitus: A Systematic Review	2007	*Evidence-based Complementary and Alternative Medicine*	115	Review
10	Head[42]	Peripheral Neuropathy: Pathogenic Mechanisms and Alternative Therapies	2006	*Alternative Medicine Review*	112	Review

Table 6: Topmost ten productive institutions of yoga-diabetic research

n	Institutions	Country	Total number of articles	Total citation	h index	Citation per article
1	All India Institute of Medical Sciences, New Delhi	India	16 (3.89)	332 (4.70)	9	20.75
2	University College of Medical Sciences	India	9 (2.19)	279 (3.95)	8	31
3	Guru Teg Bahadur Hospital	India	7 (1.7)	248 (3.51)	6	35.42
4	West Virginia University	USA	7 (1.7)	73 (1.03)	5	11.8
5	University of Pittsburgh	USA	6 (1.46)	152 (2.15)	5	10.42
6	S-VYASA University	India	6 (1.46)	28 (0.40)	3	16.6
7	Harvard Medical School	USA	5 (1.22)	289 (4.09)	4	4.66
8	Universität Duisburg-Essen	Germany	5 (1.22)	118 (1.67)	3	25.33
9	Kasturba Medical College, Mangalore	India	5 (1.22)	83 (1.18)	3	57.8
10	VA Medical Center	USA	5 (1.22)	59 (0.84)	3	23.6

S-VYASA: Swami Vivekananda Yoga Anusandhana Samsthana

Highly productive journals

Collectively, 326 Indian and International journals published 411 publications. The top 10 most productive journals published more than five papers on research around Yoga and diabetes together contributed to publishing 80 papers, which represents 19.5% share of total publication from 1975 to 2019 [Table 7]. The ranking of journals differed when the numbers of citations per journal were compared. Of these journals, the Journal of Alternative and Complementary Medicine has published the highest number of papers, which comprises 2.9% of the total publication. Out of these top 10 productive journals, Evidence-Based Complementary and Alternative Medicine, Indian Journal of Physiology and Pharmacology, Journal of Alternative and Complementary Medicine and BMC Complementary and Alternative Medicine have generated more than 200 citations. 2017 Cite score, SJR, and SNIP were compared across these journals. The highest cite score, SJR, and SNIP in 2017 was recorded in the Journal of Clinical and Diagnostic Research.

Top ten funding agencies

Funding agencies that are topmost in funding yoga diabetes research are listed in Table 8. Both the NIH and Foundation for the NIH have funded five or more projects. Of these

Table 7: Top 10 productive journals of yoga-diabetic research

Rank	Journal name	Total documents (%)	Total citation (%)	h index	Citation per article	Cite score 2017	SJR 2017	SNIP 2017	Impact factor
1	*Journal of Alternative and Complementary Medicine*	12 (2.92)	319 (4.52)	8	26.58	0.88	0.352	0.535	1.395
2	*Complementary Therapies In Medicine*	11 (2.68)	73 (1.03)	4	6.64	2.59	0.858	1.133	2.084
3	*Indian Journal of Physiology and Pharmacology*	10 (2.43)	370 (5.24)	7	37.00	1.94	0.582	0.933	0.902
4	*Evidence Based Complementary and Alternative Medicine*	8 (1.95)	418 (5.92)	6	52.25	2.54	0.845	1.128	1.931
5	*Journal of Clinical and Diagnostic Research*	8 (1.95)	27 (0.38)	3	3.38	7.81	6.693	3.847	0.65
6	*BMC Complementary and Alternative Medicine*	7 (1.70)	242 (3.43)	5	34.57	2	0.683	0.868	2.109
7	*Diabetes Care*	7 (1.70)	131 (1.86)	3	18.71	1.42	0.568	1.042	13.397
8	*Complementary Therapies in Clinical Practice*	6 (1.46)	64 (0.91)	3	10.67	0.45	0.205	0.376	1.701
9	*Indian Journal of Endocrinology And Metabolism*	6 (1.46)	31 (0.44)	4	5.17	1.6	0.571	0.785	1.157.
10	*Alternative Therapies in Health and Medicine*	5 (1.22)	182 (2.58)	5	36.40	0.82	0.352	0.67	1.329

Table 8: Top 10 funding agencies of yoga-diabetic research

Rank	Funding agency	Number of funding (%)
1	NIH	14 (3.8)
2	FNIH	5 (1.4)
3	NCCIH	4 (1.1)
4	Eli Lilly and Company	3 (0.8)
5	JNJ	3 (0.8)
6	AHRQ	2 (0.5)
7	AstraZeneca	2 (0.5)
8	BMS	2 (0.5)
9	GSK	2 (0.5)
10	March of Dimes Foundation	2 (0.5)

NIH: National Institutes of Health, FNIH: Foundation for the National Institutes of Health, NCCIH: National Center for Complementary and Integrative Health, JNJ: Johnson and Johnson, AHRQ: Agency for Healthcare Research and Quality, BMS: Bristol-Myers Squibb, GSK: GlaxoSmithKline

364 funded projects, 11 funders supported a minimum of 2 projects and one project by 85 funders among 102 agencies.

Discussion

Key findings

The current study has demonstrated several aspects of global scientific research on Yoga and diabetes and the continued growth of publications in this field during 1975–2019 using bibliometric factors and density visualizing analysis. To investigate in Yoga and diabetic research Scopus was used to achieve the goals of this study. The bibliometric profile of global publication share included 411 studies from 61 countries, most notably India and the USA, whereas the first and pioneer studies appeared in 1975. The growth rate of global publications in the year range 2010–2014 and 2015–2019 was found to be at its peak. The growth rate of global publications in the years 2015–2019 is four times high compared to the years 1975–2003. The analysis revealed that global research evidence on Yoga and diabetes has consistently increased in recent years; however, more research is warranted.

Global growth in yoga-diabetic research

Yoga has been adopted as a complementary intervention to current pharmacological treatment for T2DM.[43] Alternative therapeutic or adjunct effects of yoga intervention are generally tested as an alternative treatment to T2DM drug treatment to participants with diabetes who clinically can undergo nondrug treatment.[43] The global growth in this research has drastically increased because of an increase in global yoga participation as well as in the number of yoga practitioners and yoga schools in western countries.[7] Cramer *et al*. demonstrated that Yoga is considered as a spiritual intervention or experience by Indian participants, whereas the practice is regarded as a relaxation sport or wellness intervention in Western societies.[8]

Previous bibliometric publications on yoga interventions and diabetes

Most previous bibliometric publications on Yoga were dedicated to three topics: research trends in a western medical database from January 1950 to December 2012;[28] therapeutic intervention from 1967 to 2013,[16,27] and characteristics of randomized controlled trials (RCTs) from 1975 to 2014.[8]

Similarly, past bibliometric publications on T2DM were focused on many aspects, including most-cited publications in the microbiota of diabetes research;[44] Type 2 Diabetes Research Yield, 1951–2012;[45] Diabetes Research in Iran;[46] Global architecture of gestational diabetes research;[47] analysis of global research output on diabetes depression

and suicide;[48] Diabetic Foot Disease Research.[49] Our bibliometric profile results showed that research output escalated in 2014, 2015, and 2017 in addition to the total citation count showing the enhanced trend in research. Specifically, articles published in 2017 received more citations than other years suggesting funding opportunities for research in this area, given the increasing prevalence of T2DM.[45]

India's contribution to yoga-diabetic research

In 1975–2019, India's publication output on yoga-diabetic research was higher than the USA's publication share. Of the most productive authors, Innes, Singh, and Tandon have contributed to nine publications. Three of the most productive authors are from New Delhi, India. Looking at the most productive authors country affiliation, eight were from India, one from the USA and one from Germany. Fifty per cent of the top 10 most productive institutions are based in India. Cramer *et al*. demonstrated that the principal motives for the positive clinical outcomes in Indian yoga studies could be that yoga interventions are more intense compared to non-Indian trials. They also added that the critical reason for better performance and positive outcomes in Indian yoga studies could also be attributed to the difference in the skills of the yoga trainer.

Institutional affiliations

In general, the global growth of annual publications on any medical condition was not accompanied by an increase in inter-institutional collaboration. The number of different institutional affiliations an article associates between Yoga and diabetes remained approximately constant over time.[6] The majority of publications on yoga-diabetic research is led by research groups affiliated with one institution. Moreover, well-established research centers tend to interact domestically with authors within the same country because international collaboration might be of limited benefit for such well-established research centers.[6] Our analysis shows the two leading publishing institutions in India are New Delhi based Institutions and University College of Medical Sciences is affiliated with Guru Teg Bahadur Hospital. Of particular importance is that 50% of the most productive institutions are based in India. Collaboration with other Western developed countries particularly the USA, Australia, and UK, could be fruitful from the expertise and resources in these areas.

Journals that published the most articles

Our analysis revealed that the Journal of Alternative and Complementary Medicine was the most productive in publishing articles on yoga-diabetic research on the association between diabetes and Yoga. However, Evidence-Based Complementary and Alternative Medicine, Indian Journal of Physiology and Pharmacology, Journal of Alternative and Complementary Medicine and BMC Complementary and Alternative Medicine were heavily involved in publishing work related to yoga-diabetic research. Evidence-Based Complementary and Alternative Medicine has the highest citations and Journal of Alternative, and Complementary Medicine has the highest h-index among 326 journals.

Good quality publication output

The growth of good-quality studies will undoubtedly enhance the repository of evidence that regulate the therapeutic use of Yoga on symptomatic treatment of clinical conditions. Global research output on research that explores the association between Yoga and diabetes on using a bibliographic and density visualizing analysis of articles indexed in Scopus was measured using three indicators of quality research outputs such as total citations (percentage), h index, and average citation per article.[45] In the current study, those mentioned above critical bibliometric indicators were measured for the topmost ten productive authors, journals, countries, and institutions.

When the h-index was utilized to assess the impact of yoga-diabetic publications, the USA ranked first, followed by India. Publications from the USA attracted the highest share of citations, followed by those from India. The top-cited ten articles among 411 articles were focused on disease and healthy state of yoga intervention. Other publications were related to the different pathophysiological mechanisms of different diseases and associations of these mechanisms with cardiovascular disease, pregnancy, and diabetes mellitus. The number of the citations within this bibliometric profile was 7059, corresponding to giving an average citation count of 17 per article.

Limitations

One limitation of our study is that our bibliometric analysis did not include the articles from non-Scopus bibliographic databases such as PubMed, Google Scholar, and Web of Science. However, Scopus provides all significant indicators of bibliometric and visual density analysis. Scopus should provide a consistent and accurate overview of publication output. Therefore, it is considered a better bibliographic search engine than Google Scholar, PubMed, and Web of Science.[29]

Second, this analysis of total citations and citations per article could partly be confounded with self-citations by authors. Self-citations tend to create a bias in assessing the quality and impact of publications by authors.[50,51]

Thirdly, this study did not retrieve different institutional affiliations as well as single and multiple country publications because this information is not available for all articles, and yoga-diabetic research is primarily led by research groups affiliated with one institution.

The study demonstrated that the number of papers without citations was 121, which represents 29.44% of the total.

Based on the previous bibliometric profile of various studies, the percentage of papers without citations found in the bibliographic databases varies widely, for example, multiple sclerosis journal in 2015 (14.88%), Science in 1991 (28%), Chemistry in 1999 (27%), cardiovascular research in 2004 (34.3%), Autism spectrum disorder in 2016 (16.23%).[6,32,52]

Aleixandre-Benavent *et al*. explained that the share of uncited publications changes over the period due to delay of several years of the citation of previous papers and also highlighted that publications publishing consensus, agreements, and review articles attract more citations than others.[32] Few studies demonstrated that indicators such as h-index, journal metrics, and impact factors are not valid parameters for the quality assessment of publications. A previous Nature editorial highlighted that reading the publication and forming the opinion is the best judgment for sound quality publication output.[53,54] Our analysis has used three additional and appropriate indicators, including cite score, SJR, and SNIP, to overcome the inherent effects of the h-index and impact factor.

Future systematic reviews, meta-analyses, and randomized controlled studies

In general, summary findings of qualitative and quantitative synthesis, such as systematic reviews and meta-analyses, are based on the available literature in a given research field. The total number of publications in the other medical conditions in the systematic review and meta-analysis was not adequate to offer an excellent synthesis of the evidence to draw any definitive conclusions.[45] Therefore, prospective systematic reviews and meta-analyses are needed to test the level of evidence and strength of recommendation for yoga intervention in the T2DM state.[8] A previous meta-analysis revealed the impact and beneficial effects of a yoga intervention for asthma in 14 RCTs.[8] A previous systematic review and meta-analysis study highlighted that future randomized controlled studies could consider providing yoga intervention as an adjunct treatment to either severe cases of diabetes who have not shown any improvement with drug treatment.[43] Therefore, further well-conducted randomized controlled studies with large cohorts will give more useful information about adjunct effects of yoga intervention and potential mechanisms for patients with type 2 diabetes.

Conclusions

This study is the first bibliometric analysis of research into the association between yoga interventions and diabetes. The number of publications on this topic has increased from 1975 to 2019. The bulk of publications are published in India, USA, UK, and Germany, and this study showed that the majority of the most productive institutions and authors were based in India. There is a wide variety of journals, in which yoga-diabetic articles are published. Therefore, this study provides a helpful reference for endocrinologists, yoga therapists, policy decision-makers, and diabetes researchers.

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Conflicts of interest

There are no conflicts of interest.

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