

Evidence Base of Yoga Studies on Cardiovascular Health: A Bibliometric Analysis

Abstract

Noncommunicable diseases including coronary artery disease contribute to approximately 50% of global mortality. Pharmacological treatment alone may not be a panacea for such diseases since it may be associated with various other adverse effects. Hence, strategies such as Yoga involving healthy lifestyle and stress management are widely sought by the patient population. **Materials and Methods:** An electronic search of PubMed as a standard bibliographic database was performed through February 2015 using the keywords “Yoga” and “Cardiovascular.” Studies with Yoga as the independent variable and parameters related to cardiac health as the dependent variable were included and exclusion criteria were applied. **Results:** A total of 149 publications were identified which met the inclusion criteria for analysis. Of the total publications, 44% were clinical trials of which 19% were randomized controlled trials which may be categorized as high-quality ones. An upward trend in the overall research in this area is evident. Major work has been accomplished by researchers of the United States (38%) and India (29%). **Conclusion:** The survey indicates that the number of publications in the field of “Yoga” and “Cardiovascular” health has increased rapidly in the late years. Analysis comprising the nation/state helps define its status with regard to its counterparts and helps understand science priorities and disease control strategies in an effort to provide cost-effectiveness and quality control. There is a need for further high-quality studies in the field of “Yoga” and “Cardiovascular” diseases to validate the effects of Yoga on health parameters.

Keywords: *Bibliometrics, cardiovascular, yoga*

Introduction

Noncommunicable diseases such as coronary artery disease (CAD), cancer, diabetes, and chronic obstructive pulmonary disease put together contribute to 50% of global mortality. Of these, cardiovascular disease (CVD) is known to be the number one cause of death and disability worldwide (WHO 2011). Around 29.6% of total global deaths can be attributed to CVD (WHO 2003). It is estimated that by 2030, CVDs will account for almost 23.6 million deaths (WHO 2011).^[1,2] Several risk factors such as smoking, high-fat diet, sedentary lifestyle, and psychological factors, including stress, depression, and hostility contribute to coronary heart disease.^[3] The pharmacological treatment used for treating CVD has limited efficacy along with various adverse effects. Therefore, there is an upsurge in patients opting for other strategies for healthy lifestyle and stress management in an

attempt to improve health-related quality of life and to prevent recurrent illness. Yoga is the alternative strategy patients prefer since it involves both stress management and exercise. It is one of the most popular complementary and alternative medicine (CAM) practices, incorporating Asanas (postures), Pranayama (breathing exercises), Dhyana (meditation), and certain philosophical principles to create a sense of well-being.^[4,5]

More recently, its therapeutic aspect has been validated in a range of medical conditions such as psychopathological, cardiovascular, respiratory, and metabolic diseases. Under the broad umbrella of CAM, Yoga therapy is being recognized worldwide as an alternative approach to many health-related issues.^[6] A general feature of these practices is their capability of inducing psychophysiological balance. It is postulated that Yoga practice improves CVD-related outcome through following two pathways,

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Access this article online

Website: www.ijoy.org.in

DOI: 10.4103/ijoy.IJOY_6_18

Quick Response Code:



How to cite this article: Sharma KN, Choudhary NR, Subramanya P. Evidence base of yoga studies on cardiovascular health: A bibliometric analysis. *Int J Yoga* 2019;12:162-71.

Received: February, 2018. **Accepted:** August, 2018.

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vagal stimulation and parasympathetic activation as shown in Figure 1.^[7] Yoga’s therapeutic potential in the field of cardiovascular health has been explored in a growing number of trials to date although consolidation of evidence as bibliometric analysis is limited. Hence, the purpose of the present study is to provide a comprehensive review of available research evidence in the field of cardiovascular health through a bibliometric analysis.

Materials and Methods

Data source

An electronic search of PubMed as a standard bibliographic database was performed through February 2015 using the keywords “Yoga” and “Cardiovascular.” Studies with Yoga as the independent variable and parameters related to cardiac health as the dependent variable were included and exclusion criteria were applied [Figure 2].

Study selection

The search strategy was built basically by inputting the keywords “Yoga” and “Cardiovascular.” The country of origin of the article was identified by the first author’s country. After removal of duplicate records, identified abstracts were screened independently by two review authors (SSKN and CNR) to determine whether they actually met the eligibility criteria.

Selection criteria

The following selection criteria were applied to include or exclude the studies:

Types of studies

Each study was evaluated as to the presence of a control group and whether participants were randomized to different study arms, to yield three possible study categories: noncontrolled trials, controlled trials, and randomized controlled trials (RCTs). Dissertations, reports or proceedings of meetings, book chapters, articles in foreign language, and those not matching with the keywords, i.e. non-Yoga intervention as well as noncardiovascular outcomes were excluded. Reports or research letters in journals, publications of case reports, and population survey studies and articles with minimum literature availability which were insufficient to categorize have not been included. Although the reviews, meta-analysis, bibliometric analysis, Cochrane reviews, and pilot studies have not been included for analysis, they have been reported in the overall review with respect to the year of publication and place of the origin.

Types of participants

Studies of all types of participants were eligible. No restrictions were applied regarding sociodemographic characteristics, age, and gender or health status.

Types of interventions

Studies were eligible if they assessed the effects of Yoga interventions. Studies were selected irrespective of the tradition, length, frequency, or duration of the Yoga practice. There was no restriction on the inclusion of precise practices provided, the stated practice had a theoretical historical past in Yoga or has been in Yoga

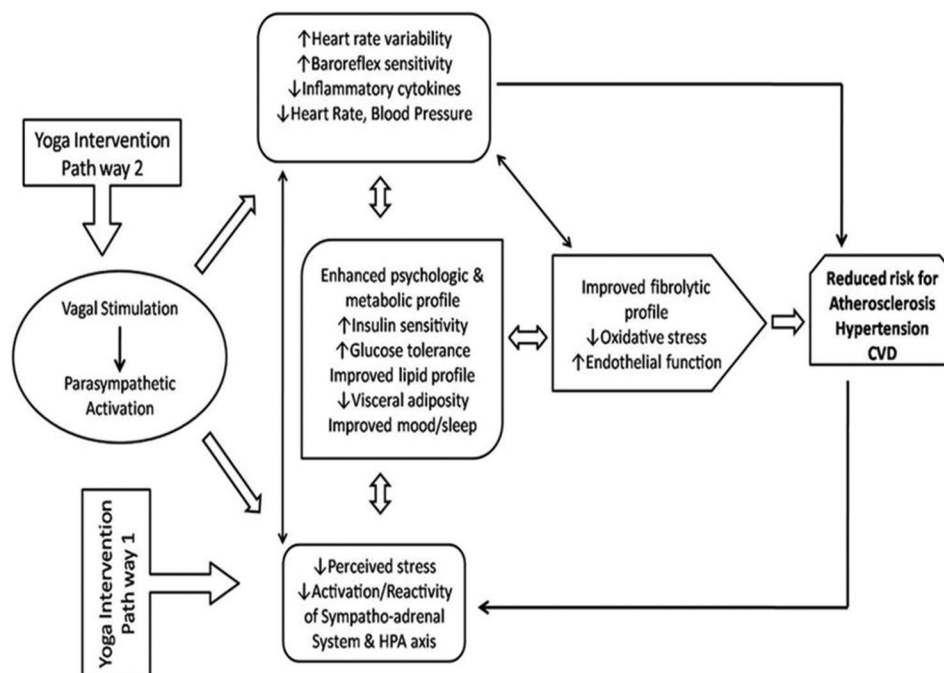


Figure 1: Flowchart of the yoga intervention pathway. The full form of abbreviations is as follows: HPA = Hypothalamic pituitary adrenal and CVD = Cardiovascular disease

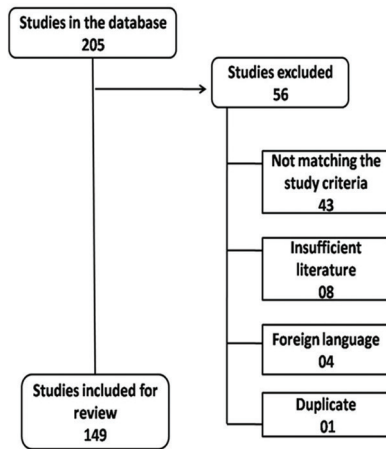


Figure 2: Flowchart depicting study selection

practice traditionally. Intervention components such as Asanas (Yoga postures), Pranayama (Yoga breathing techniques), and Dhyana (meditation) were included along with educational sessions on the philosophy of Yoga, Yogic diet, and/or Yogic lifestyle. Studies involving individual co-interventions along with the intervention that was formally studied were included, but those with multimodal interventions were not. No restrictions were applied to control group interventions.

Data extraction

Two authors (SSKN and CNR) independently extracted data using a standardized data extraction form. All relevant data on study design and settings, types of participants, interventions, and outcome measures were extracted and recorded in the data extraction form. We resolved disagreements by consensus or discussion with the third author (SP). The structured data extraction form consisted of the following: (a) publication information (publication year and origin), (b) data on participants (sample size, gender, age, and medical condition), (c) intervention (yoga tradition, program length, intervention components, and control intervention), and (d) outcome measures and conclusion (changes in blood pressure and blood lipids, cardiovascular mortality, myocardial infarction, CABG, stroke, quality of life, and psychological states).

Data analysis

We performed data analysis using SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc. Data were presented by counts, percentages, and frequency.

Results

Study characteristics

Of the total of 149 studies, 44% were interventional studies. Among these, the share of RCTs was 19% that of non-RCTs 13% and that of noncontrolled trials were 13%. Next in the hierarchy was occupied by

systematic reviews which amounted to 26% of the total studies. Apart from these, 15% of them were one-time studies while another 15% comprised miscellaneous ones, namely, pilot studies, case reports, meta-analysis, surveys, interviews, scientific statements, bibliometric analysis, Cochrane reviews, and letters to the editor, each of which shared a meager percentage. There is an upward trend in the quantum of research work published in this field from the year 1961 onward. There was a minor upsurge compared to the previous couple of decades, with the total number of reaching 17 between the years 1990 and 1999. There was a drastic change in the trend during the subsequent decade, with the number of publications rising up to 59 by the year 2009, with each year consistently contributing to the field of research in this area, the contribution of the year 2007 is the highest at 10 research papers. With a good beginning of 13 publications in the year 2010, the next 5 years saw a tremendous growth in the field of research in “Yoga” and “Cardiovascular” health with the number of research articles published crossing the total number of publications of all the previous years until then reaching the digit “110.” The years 2011 and 2014 were the highest contributors with the number of published articles summing up to 28 and 27, respectively.

The United States (US) (38%) and India (29%) share the majority of research contributions in the field of Yoga and cardiovascular health. This is followed by the United Kingdom, Australia, and Canada with their contributions of 5%, 4%, and 3%, respectively. Others share between 1% and 2% each among the remaining 20% of the publications. The origin of another 4% of the published studies could not be traced.

The randomized controlled trials

RCTs, which are considered the gold standard in experimental studies, were first carried out in this area by the year 1989 for this literature study. It gained momentum by the year 2011 when 25% of all publications in the field were RCTs. This was followed by 18% in 2012, 11% in 2013, and 21% in 2014. India contributed a high of 36% RCTs, followed by the US with 32%, while Australia and Korea share 7% each with only a meager percentage to be shared among UK, Jamaica, Israel, Brazil, and Iran. The trials were conducted on a wide range of populations, including healthy adults, hypertensive participants, diabetics, older adults, heart failure participants, and patients with CAD, and the duration of trial ranged from 8 weeks to 56 weeks, with the majority of the studies incorporating the intervention duration of 12 weeks [Figure 3]. The majority of the studies incorporated the integrated Yoga intervention in combinations of Asanas and Pranayama, and in a few, meditation was also included. The detailed literature review table for the RCTs has been provided in Table 1.

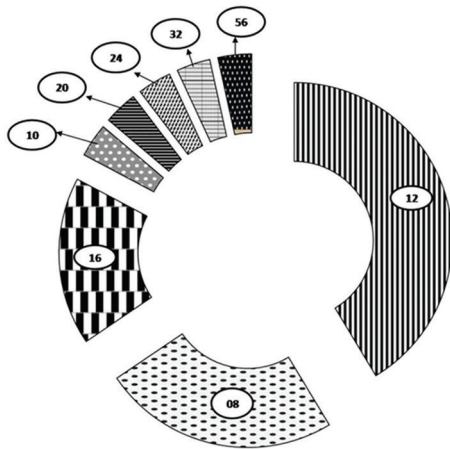


Figure 3: Yoga duration in weeks. Doughnut chart illustrating the Yoga intervention period in weeks incorporated in different trials. (24% of studies incorporated 8-week duration, 4% incorporated 10 weeks, 41% incorporated 12 weeks, 17% incorporated 16 weeks, 4% incorporated 20 weeks, 4% incorporated 24 weeks, 4% incorporated 32 weeks, and 4% incorporated 56-week duration of yoga practice)

The nonrandomized controlled trials

In a span of over 40 years, i.e., between the years 1975 and 2015, we came across 19 non-RCTs. The majority of the trials were from the recent 15 years. Six of the 19 trials originated from the US, while five were from India. Healthy yoga practitioners, hypertensive, and geriatric population predominated the study population apart from sedentary people, smokers, and those infected with HIV [Figure 4]. The duration of the trial ranged from 0 to 48 weeks.

The single group studies

Nineteen studies fitting into the single group design category were documented post-1997, with 2011 contributing the maximum numbers. Pranayama is the most frequently used Yoga practice, with 10 of 19 studies incorporating this along with, asana, meditation, educational sessions, and yoga-based lifestyle modifications. The duration of trial ranged from 0 to 12 weeks. Blood pressure (12 studies) and heart rate (11 studies) were the most evaluated outcome measures.

The one-time studies

Studies carried out over a single time period were categorized as “one-time” studies. The first such study was documented in the year 1987, and until date, there are 22 such studies in total making up to 15%. India, the US, and Czechoslovakia, respectively, contributed 6 (27%), 5 (23%), and 3 (14%) such studies. Most of the studies have been conducted on Yoga practitioners and healthy population, while a few were for Duchenne muscular dystrophy children, Parkinson’s, dementia patients, the sedentary population, as well as runners.

Discussion

This bibliometric analysis reflects a comprehensive review to date of the clinical evidence on Yoga for cardiovascular

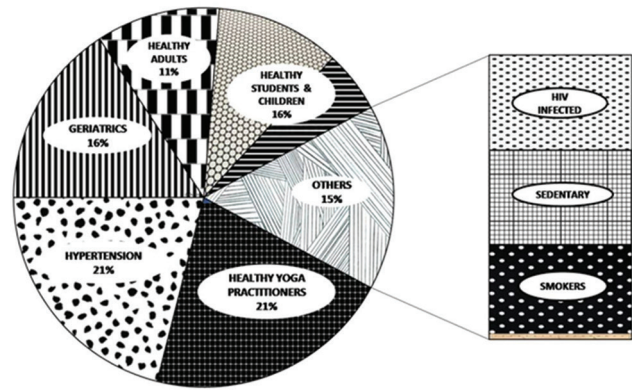


Figure 4: Study population in non-randomized controlled trials. Bar pie chart illustrating the population recruited for the non-randomized controlled trials. The full form of abbreviations is as follows: HIV = Human immunodeficiency virus

health, including reviews, RCTs, non-RCTs, case reports, and surveys. Of 149 trials included in the review, only 19% were randomized controlled studies. Most of the trials were short term and conducted on healthy participants. The information gaps in the published literature are highlighted here. There is a lack of reliable, strong evidence on the effects of Yoga on clinical events, blood pressure and lipid levels and for the primary prevention of CVD. There is an increment in the publications in the past one decade; nonetheless, more trials are needed to clarify the potential benefits of Yoga for cardiovascular health. “Previous systematic reviews studied the efficacy of Yoga in the primary and secondary prevention of CVD” (Innes 2005; Jayasinghe 2004). “The majority of the identified studies focused on primary prevention, and only a few identified studies investigated secondary prevention. This may reflect under research on this topic. A population-based study suggested a substantial growth in the use of Yoga as a form of CAM” (Barnes 2008). Nevertheless, the participants exhibit a trend to utilize CAM to treat musculoskeletal problems rather than chronic diseases, namely, lifestyle disorders. The low prevalence of the Yoga might limit exploration of the therapeutic potential of Yoga.

Ugolini *et al.* in a bibliometric analysis of the fields on the rehabilitation of cerebrovascular and CVDs have come up with similar findings and have reported that the publications in this area increased 8.6 times from the year 1967 to 2008, and after a 20-year period of plateau between 1975 and 1994, there is an addition in the productivity of cardiovascular research in the past 15 years.^[8,9] Major work in this field has been carried out by the researchers from the US and India and the findings of which are consistent with the results of Khalsa in his study on therapeutic Yoga.^[10]

Healthy and individuals suffering from hypertension are frequently recruited for the trials. Possibly because the physiological effects of Yoga practice as well as the mechanism of action of a majority of practices are

Table 1: Literature review table for the randomized controlled trials

Study title	Journal	Year of publication	Groups	Sex	Age group	Intervention	Duration of intervention	Study population	Origin of study	Outcome measures
Effect of yoga regimen on lung functions including diffusion capacity in coronary artery disease patients: A randomized controlled study	Int J Yoga	2015	2	Both	<65	asana, pranayama, diet, holistic teaching	12 weeks	CAD patients	India	Lung function with diffusion capacity
Randomized controlled trial of a 12-week yoga intervention on negative affective states, cardiovascular and cognitive function in postcardiac rehabilitation patients	BMC complement Altern Med	2014	2	Both	NA	asana, pranayama, meditation	12 weeks	Postphase 2 cardiac rehab patients	Australia	Depression anxiety stress scale
Additional benefit of yoga to standard lifestyle modification on blood pressure in prehypertensive participants: A randomized controlled study	Hypertens Res	2014	2	Both	20-60	Yoga and life style modification	12 weeks	Pre-HTN without any CVD	India	BP, HR
Effect of yoga on oxidative stress in the elderly with Grade-I hypertension: a randomized controlled study	J Clin Diag Res	2014	2	Male	60-80	Yoga	12 weeks	Grade - I HTN	India	Serum (oxidative stress and antioxidants), Vitamin C
Age-related changes in cardiovascular system, autonomic functions, and levels of BDNF of healthy active males: role of yogic practice	Age (Dordr)	2014	3	Male	20-49	Yoga	12 weeks	Healthy	India	HR, BP, myocardial oxygen consumption, skin conductance
Preventive effects of a 3-month Yoga intervention on endothelial function in patients with migraine	Int J prev Med	2014	2	Female	NA	Yoga training	12 weeks	Migrane	Iran	Plasma endothelial function
Effect of yoga therapy on heart rate, blood pressure, and cardiac autonomic function in heart failure	Clin Diagn Res	2014	2	Both	NA	Yoga therapy	12 weeks	Heart failure	India	HR, BP, HRV, rate pressure product
Effect of fast and slow pranayama on perceived stress and cardiovascular parameters in young health-care students	Int J Yoga	2013	3	Both	18-25	Fast and slow pranayama	12 weeks	Health care students	India	HR, BP, perceived stress, rate pressure product, double product

Contd...

Table 1: Contd...

Study title	Journal	Year of publication	Groups	Sex	Age group	Intervention	Duration of intervention	Study population	Origin of study	Outcome measures
CALM-BP: A randomized controlled trial of a multifactorial lifestyle intervention	J Hum Hypertens	2013	2	Both	NA	Yoga relaxation, stress management	16 weeks	Hypertensive	Israel	BP, BMI, cholesterol, QoL
Effect of exercise therapy on lipid parameters in patients with end-stage renal disease on hemodialysis	J Lab Physicians	2012	2	Both	NA	Hatha Yoga exercises	16 weeks	End stage renal disease	Jamca	Serum lipids
Yoga training improves metabolic parameters in obese boys	Korean J physiol Pharmacol	2012	2	Male	14	Yoga-asana	8 weeks	Obese adolosest	Korea	Body composition, lipid profile, insulin resistance
Bikram yoga training and physical fitness in healthy young adults	J strength cond Res	2013	2	Both	NA	Bikram Yoga	8 weeks	Healthy	USA	Isometric strength, hand grip, flexibility, max oxygen consumption, BP, HR, aerobic fitness
The effects of a gentle yoga program on sleep, mood, and blood pressure in older women with RLS: A preliminary randomized controlled trial	Evidence Based Compliment Alt Med	2012	2	Female	NA	Yoga	8 weeks	Restless leg syndrome	USA	Sleep, mood, stress, BP, HR
Effects of an 8-month yoga intervention on arterial compliance and muscle strength in premenopausal women	J sports Sci Med	2012	2	Female	35-50	Astanga Yoga	32 weeks	Healthy premenopausal	USA	Arterial compliance, muscle strength
Nonpharmacological interventions in hypertension: A community-based cross-over randomized controlled trial	Indian J community Med	2011	4	Both	NA	Yoga, walking, exercise	8 weeks	Prehypertensive, hypertensive	India	BP
Effects of yoga exercise on serum adiponectin and metabolic syndrome factors in obese postmenopausal women	Indian J community Med	2012	2	Female	55	Yoga	16 weeks	Obese postmenopausal	Korea	Serum adiponectin and metabolic syndrome factors
A comparative study of slow and fast suryanamaskar on physiological function	Int J Yoga	2011	2	Both	12 to 16	Suryanamaskar	24 weeks	Healthy school children	India	BP, PFT, Handgrip strength and hand grip endurance

Contd...

Table 1: Contd...

Study title	Journal	Year of publication	Groups	Sex	Age group	Intervention	Duration of intervention	Study population	Origin of study	Outcome measures
Yoga respiratory training improves respiratory function and cardiac sympathovagal balance in elderly participants: A randomized controlled trial	BMJ Open	2011	2	Both	65-75	Bhastrika	16 weeks	Healthy	Brazil	PFT, inspiratory and exp pressures, BP variability, HR variability
Association of fructosamine to indices of dyslipidemia in older adults with type 2 diabetes	Diabetes metab Synd	2011	2	Both	>45	Yoga	8 weeks	Type 2 DM	United States	HbA1C, serum lipid
Effect of an office worksite-based yoga program on heart rate variability: a randomized controlled trial	BMC public Health	2011	2	Both	NA	Asana, vinyasa pranayama, dhyana	10 weeks	Sedentary office workers	Australia	HRV
Effect of integrated yoga practices on immune responses in examination stress - A preliminary study	Int J Yoga	2011	2	Both	NA	Integrated Yoga	12 weeks	Healthy 1 st year MBBS students	India	HR, BP, RR, stress, anxiety
A new educational film control for use in studies of active mind-body therapies: Acceptability and feasibility	J Altern Complement Med	2011	2	Female	NA	Yoga (vs. educational film as control)	8 weeks	Postmenopause with CV risk	USA	End of the study questionnaire
Yoga lifestyle intervention reduces blood pressure in HIV-infected adults with cardiovascular disease risk factors	HIV Med	2010	2	Both	NA	Yoga practice	20 weeks	HIV infected adults with CVD risk	USA	CVD risk, virological/ Immunological status, QoL
Benefits of yoga for African American heart failure patients	Med Sci Sports Exerc	2010	2	Both	NA	Yoga therapy	8 weeks	Heart failure- African American	USA	Cardiovascular endurance (VO2 peak), flexibility, QoL, and inflammatory markers
Community-based yoga classes for type 2 diabetes: An exploratory randomized controlled trial	BMC Health Ser Res	2009	2	Both	NA	Yoga	12 weeks	Type 2 DM	UK	HbA1c, t circumference, lipid levels, blood pressure, UKPDS cardiovascular risk score, diabetes-related quality of life (ADDQoL), and self-efficacy

Contd...

Table 1: Contd...

Study title	Journal	Year of publication	Groups	Sex	Age group	Intervention	Duration of intervention	Study population	Origin of study	Outcome measures
Effects of Hatha yoga and Omkar meditation on cardiorespiratory performance, psychologic profile, and melatonin secretion	J Altern Compliant Med	2004	2	Male	25-35	Asanas, pranayama, Omkara meditation	12 weeks	Healthy	India	Orthostatic tolerance, heart rate, blood pressure, respiratory rate, dynamic lung function (such as forced vital capacity, forced expiratory volume in 1 second, forced expiratory volume percentage, peak expiratory flow rate, and maximum voluntary ventilation), and psychologic profile
Effects of exercise training on cardiorespiratory function in men and women older than 60 years of age	American J Cardiol	1991	3	Both	>60	Yoga	56 weeks	Older adults	USA	Aerobic capacity, blood lipid
Cardiovascular and behavioral effects of aerobic exercise training in healthy older men and women	J Gerontol	1989	3	Both	67	Yoga	16 weeks	Older adults	USA	Physiological measures included measurement of blood pressure, lipids, bone density, and cardiorespiratory fitness including direct measurements of peak oxygen consumption (VO2) and anaerobic threshold. Psychological measures included measures of mood, psychiatric symptoms, and neuropsychological functioning

CAD=Coronary artery disease, HTN=Hypertension, CVD=Cardio vascular disease, DM=Diabetes mellitus, CV=Cardio vascular, HIV=Human immunodeficiency virus, BP=Blood pressure, HR=Heart rate, HRV=Heart rate variability, BMI=Body mass index, QoL=Quality of life, PFT=Pulmonary function test, HbA1C=Hemoglobin A1C (glycated hemoglobin), RR=Respiratory rate, VO2=Volume of oxygen, UKPDS=United Kingdom Prospective Diabetes Study, CALM-BP=Comprehensive Approach to Lower Blood Pressure, RL.S=Restless Legs Syndrome

beginning to be clear of late, the trials involving healthy population could help accomplish the task. Yoga is known to inhibit sympathetic activity and facilitate parasympathetic activity. Contrary to conventional exercises, Yoga aims at minimizing oxygen uptake by inducing relaxation. All these practices aim at increasing awareness of the working heart and attempt to reduce heart rate. Therefore, it is commonly adopted by hypertensive individuals as an alternative way to manage such chronic conditions. Blood pressure and heart rate being the direct reflection of autonomic nervous system activity are the commonly used outcome measures followed by lipid profile and aerobic fitness. Moreover, both of these measures are valid, reliable, noninvasive, easily measurable, and cost-effective ones.

Conclusion

The literature survey indicates that the number of publications in the field of “Yoga” and “Cardiovascular” health has increased rapidly in the past few years. The US and India contributed most of the publications. The study further attempts to represent the outcome focusing on Indian states, mainly because India is a major contributor in this field and also since information about this geographical region is sparse. Analysis comprising the nation/state helps define its status about its counterparts and helps understand science priorities and disease control strategies to provide cost-effective and quality control. The literature analysis reveals a deficiency of high-quality studies recruiting patient population in the area of cardiovascular health for Yoga trials. Hence, further high-quality studies investigating the potential effects of Yoga in the management of CVDs may be recommended.

Limitations

The PubMed database was the solitary source of information. Journal publications other than the English language were excluded from the review. Consequently, states with a tradition of bringing out publications in their native languages may be underrated in this recapitulation. The possibility of bias also exists in not considering several unpublished studies in our review. The primary investigators of some identified studies were contacted to obtain additional methodological information to inform our determination as to whether these surveys should be admitted; all the same, most investigators did not respond to our inquiry e-mails. We cannot, therefore, avoid the possibility that we may not have included some eligible studies.

Implications for research

More high-quality RCTs may be recommended to obtain a definitive response to the inquiry of the strength of Yoga for cardiovascular wellness. Emphasis to better methodological quality should be given in the future studies with respect to the design of trials, random

sequence generation, group blinding, sample size, sample power, and avoidance of bias in the study to improve the methodological quality. Tests should include relevant issues such as morbidity, composite cardiovascular events, and quality of life. So also, valuation of the cost as well as documentation of cardiovascular-related hospital admissions and untoward results are prescribed. Participants from different ethnic groups and from different countries could be considered as part of a more widespread research. On the basis of the findings of the current study, we advocate an integrated approach toward Yoga incorporating various combinations of asanas, pranayama, kriyas, meditation, and relaxation practices along with lectures and advice on yoga-based lifestyle modifications and diet while addressing the needs of cardiovascular patients. We also recommend an intervention duration of a minimum of 12 weeks for the effects to manifest in such population. Special consideration needs to be given to individual practice as a home program. Biomarker studies which compare Yoga with standard pharmacological and psychotherapies, and studies of long-term efficacy are needed to fully translate the promise of Yoga in the field of cardiac health.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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