

The ROLE of Yoga Practice in Management of Coronary Artery Disease

Swati Kumari¹, Neelam Dahiya^{2*}, Manjari Rain³, Rupesh Kumar⁴ and Gurmeet Singh⁵

¹ICSVS, Panjab University, Chandigarh, India

²Department of Cardiology, PGIMER, Chandigarh, India

³Neuroscience Research Lab, Department of Neurology, PGIMER, Chandigarh, India

⁴Department of Yogic Art and Science, Visva Bharati University, West Bengal, India

⁵Department of Physical Education, Panjab University, Chandigarh, India

KEY WORDS

Yoga
CVD
CAD
Cardiac Rehabilitation
Hypertension
Quality of life
Alternative therapies

*Corresponding Author:

Neelam Dahiya

Department of Cardiology
PGIMER, Chandigarh, India
Contact no: +91-9876386810
E-mail: drneelamdahiya@gmail.com

ABSTRACT

Background: Yoga has quickly risen to one of the common complementary and alternative medicine practice worldwide. Yoga has been useful in primary and secondary prevention of cardiovascular disease (CVD) including coronary artery diseases (CAD). Many evidences suggest that Yoga is safe and efficacious in reducing various risk factors of CAD such as stress, anxiety, depression, diabetes and hypertension. Yoga also improves quality of life, and reduces other psychological burdens in patients of CAD.

Summary: We intend here to look into the available literature on the role of Yoga in CAD, how Yoga can be an alternative and cost-effective model for cardiac rehabilitation worldwide, especially in low-income countries.

Key message: Yoga has been associated with improvement in general health, prevention of cardiovascular risk factor and of other non-communicable diseases. Yoga has shown improvement in BMI, blood pressure, lipid profile, slows lesion progression in CAD. However, the biomolecules through which Yoga acts on body is unclear in CAD. There should be emphasis on yoga practice at community level which is the need in current era.

doi: 10.38205/imcr.030269

Introduction

Cardiovascular diseases (CVDs) are the leading cause of morbidity and mortality globally. It includes diseases of heart and vasculature including coronary heart diseases (CHD), or coronary artery diseases (CAD), stroke and peripheral vascular diseases. According to WHO estimates, in 2019, 32% of overall deaths and 38% of premature deaths were due to CVDs. Significant number of premature cardiovascular deaths were from lower-middle-income countries like India (1). According to WHO, cardiovascular diseases (CVDs) are the main reason of death all over the world, estimated death is around 17.9 million each year (2). CHD cases have increased by 74.9% from 1990 to 2017 (3). The annual direct and indirect financial burden of heart disease is estimated to be around \$218.7 billion from 2014 to 2015 in USA alone. Further, 6.7 out of 100 adults in the United States are living with heart disease (4). Due to its high prevalence and high mortality, CVD caused a substantial socio-economic burden worldwide. The increasing CVDs are additional burden on overwhelmed health care system in India.

Cardiac rehabilitation (CR) is a multidisciplinary program that includes exercise training, psychosocial support, self-awareness in patients of CVD and education about lifestyle changes to reduce morbidity and mortality. Unfortunately, CR

has been an unmet need in India. Yoga can be an alternative to CR. *Yoga* involves mind-body connection and alignment with higher consciousness. Traditional Yoga includes not only physical postures, it have a wider aspect which includes *Yama, Niyam, Asana, Pranayam, Pratyahara, Dharna, Dhyana* and *Samadhi*. Yoga postures or *Asanas*, breathing exercises called *Pranayama*, meditation, and chanting are parts of Yoga. These Yoga practices help to align oneself at physical, emotional, mental, social, and spiritual dimensions with universal consciousness imparting a state of wholeness, harmony, and well-being. Yoga has been considered beneficial for overall physical and mental health, also increases life expectancy with proper and prolonged practice (5). Many studies have shown that Yoga leads to reduction in oxidative stress, which is considered to be a causative factor in a number of ailments in body (6).

This review looks into the available literature on the role of Yoga in cardiac rehabilitation (CR) as an alternative and cost-effective model worldwide, especially in low-income countries.

Yoga and risk factors of coronary diseases

Usually, CAD is preceded by the development of various risk factors, which are modifiable and non-modifiable. The most

common modifiable risk factors for CAD are sedentary lifestyle, smoking, obesity, hypertension, diabetes, and dyslipidaemia (7). Hypertension is one of the leading causes of ischemic heart disease, stroke and can also lead to renal failure. In order to prevent such disabling disease, adequate control of hypertension is crucial. As early as 1975, a Yoga trial has been reported to improve blood pressure and reduce drug requirements in hypertensive patients (8). Also, Yoga decreases pro-inflammatory adipokines (leptin and chemerin) along with improvement in anti-inflammatory adipokines (adiponectin) in patients with metabolic syndrome and high and normal BP (9). In a recent study, *Asana*, *Pranayama*, and Meditation were practiced by hypertensive patients for four months, and led to a 7 mm Hg reduction in systolic and 5.3 mm Hg reduction in diastolic blood pressures (10). Yogic postures such as *Ardha-halāsana*, *Ardha-pavanmuktāsana*, *Bhujangāsana*, *Makarasana*, *Paschimattanasana*, *Vakrasana*, *Parvatasana*, and *Chakrasana* were practiced in the study. A meta-analysis published in 2017 reports that patients above 60 years of age showed improvement in blood pressure in response to meditation, whereas those below 60 years showed improvement in blood pressure in response to different yogic postures (11). Also, Yoga has been shown beneficial in pre-hypertensive individuals, effective in controlling hypertension, and preventing the onset of hypertension at the community level (12,13). Endothelial function is also improved by Yoga in CAD (14). Even though Yoga reduces blood pressure but the mechanism is unclear yet.

Another risk factor is diabetes mellitus which increases risk of CAD and stroke in men and women (15). Yoga has been shown to improve glycaemic control and reduce adverse events associated with diabetes. *Surya namaskar*, a pre-defined series of Yogic postures, leads to insulin production (16). Various other *Asanas* improve pancreatic function, blood supply, and enhance insulin's sensitivity. Other components of Yoga like *Pranayama* and Meditation also have beneficial effects on diabetic patients (13). Yoga improves blood sugar levels, BMI, and lipid profile, decreasing adverse effects in diabetic patients (17).

Dyslipidaemia is also a contributor in occurrence of CAD. Approximately 79% of the Indian population have at least one abnormal lipid parameter. A specific protocol for Diabetes management was developed by Swami Vivekananda Yoga Anusandhan Sansthan (S-VYASA), Bangalore, India, called the Diabetes Yoga Protocol (DYP). It has been shown that DYP for three months in diabetic patients led to decreased total cholesterol and improved HDL levels (18). In another community-based trial involving a large number of participants, there was an improvement in lipid parameters of both low and high baseline lipid levels (19). Another study on 72 obese subjects showed a reduction in body weight and percentage body fat in the Yoga group compared to the control group (20). Patil et al. compared the effect of Yoga vs walking in elderly patients on resting heart rate, diastolic time, ventricular ejection time, upstroke time, ejection duration index, pre-ejection period, rate pressure product, and

mean arterial pressure. After three months of Yoga practice, there was an improvement in diastolic function with little change in systolic function (21).

Obesity, as a result of a sedentary lifestyle, has brought along myriad complications such as diabetes, heart failure, obstructive sleep apnoea, etc. A meta-analysis reported that the waist circumference in healthy individuals was lower in the Yoga group than in the control group. Also, there was weight reduction in obese subjects (22). Many other studies reported an improvement in BMI with Yoga as a form of physical activity (23).

Yoga as secondary prevention in CAD

Though yoga has been found effective in the primary and secondary prevention of CAD, results have been suboptimal in definitive tough events such as major adverse cardiovascular events (MACE) and improvement in left ventricular ejection fraction (LVEF). Most studies have analysed changes in CVD risk factors like lipid levels, BMI, and quality of life with Yoga as outcomes in CAD patients. But reports on improvement in LVEF and MACE are very scarce. In a study on a small number of CAD patients, the quality of life was improved, but no improvement in LVEF was observed (24). Introducing Yoga as adjunct therapy is beneficial than standard care alone in terms of cardiac function and reduced myocardial stress (25).

Another study, in the year 2000 with a small number of participants, have shown regression of atherosclerotic plaque with Yoga (26). Yogendra et al. in 2004, evaluated CAD patients based on the clinical parameters, myocardial perfusion studies and angiography. After Yoga practice, lipid levels were improved, there was a delayed progression of disease on perfusion studies and angiographic evaluation. Also, there was no adverse effect of Yoga during the study period (27). In a meta-analysis of six RCTs, primary outcome (all-cause mortality and health-related quality of life) and secondary outcome (composite cardiovascular outcome, exercise capacity and cardiovascular risk factors) were analysed among CAD patients. In the Yoga group, the quality of life was improved, but there was no benefit in all-cause mortality. Further, there was no significant improvement in composite cardiovascular outcome and lipid profile (28).

Bruce et al. in a systematic review, found that only three among the six studies have analysed LVEF as an outcome (30). In one study, there was improvement in LVEF in post CABG (Coronary Artery Bypass Graft) patients after Yoga intervention. Those with reduced LVEF at baseline in the Yoga group showed improvement at the end of one year. The second study did not report any difference in LVEF between the groups; however, it was a short duration intervention.

Prabhakaran et al. have recently studied the effect of Yoga on MACE as a primary outcome in post-acute myocardial infarction patients (Yoga-CaRe Trial). With more than 1900 patients each in the yoga group and enhanced

standard care group, it was the largest multicentre trial involving many centres from India. The primary outcome in this trial was MACE which was the composite outcome of non-fatal myocardial infarction, any death, non-fatal stroke or hospitalization. Median follow up in this study was of 21.6 months. At the end of the study, MACE was 6.7% in the Yoga-Care group and 7.4% in the enhanced standard care group, with no statistically significant difference. There was less cardiac re-hospitalization in the Yoga group, and those with previous coronary artery disease without diabetes fared better (31).

Role of Yoga was also explored on heart rate variability (HRV) in post-myocardial infarction patients. There was a significant difference in frequency domain parameters in the Yoga and enhanced care group, with HF power and total power (nu) increased in Yoga group. HRV time-domain indices were the same in both groups. Thus, Yoga seems to change the sympathetic predominance to parasympathetic dominance and increases overall HRV in these patients (32). Further, a study was done on post-STEMI patients to see the effect of *Hath Yoga* on cardiac hemodynamic parameters and physical capacity. The study duration was just 24 days. LVEF and Spiroergometric test parameters improved in both the control and Yoga groups. However, changes were more marked in the Yoga group. Left ventricular end-diastolic and end-systolic diameter and heart rate also improved over time in the Yoga group (33).

Modulation of inflammatory pathways with Yoga

Long-standing physical or emotional stress leads to up-regulation of pro-inflammatory and down-regulation of anti-inflammatory pathways. Alteration on the cellular milieu causing increment in inflammatory cytokines leads to atherosclerosis, eventually causing CAD (34). Yoga and other mind-body therapies have been found beneficial in correcting this harmful altered cellular balance. In a study on heart failure patients, eight weeks of Yoga showed a reduction in interleukin 6 (IL-6) and CRP (C-Reactive Protein), along with an increase in extracellular dismutase (35).

Morgan et al. reported improved CRP levels in disease conditions but no change was seen in healthy adults after Yoga intervention. There was no effect on IL-6 and Tumour Necrosis factor- α (36). Yoga improves CD-3 and CD-4 cells, normalises serum cortisol levels, and increases IgA levels, thus enhancing innate immunity. Yoga also reduces oxidative stress by decreasing reactive oxygen species in the body (37). Genes involved in the regulation of inflammatory pathways show enhanced expression in chronic stressful situations. In this case, yoga helps by inhibiting the NF-kB pathway, thus reducing inflammatory cytokine production (38). Yoga also decreases BDNF (Brain Derived Neurotrophic Factor) and glucocorticoid receptor gene methylation, positively modifies several other genes, and improves Telomerase maintenance (39).

Cardiac rehabilitation (CR) program in India

CR on CAD patients has been shown to improve morbidity and mortality. It is an economic burden to patients as it involves multiple specialists such as trained nurses, physical rehabilitation specialists, cardiologists and others. Moreover, there are very few centres in India that offer CR. The number of enrolments are also negligible. International Council of Cardiovascular Prevention and Rehabilitation conducted a global CR audit and survey in 2020. out of 23 centres, 18 responded to this survey. It was found that there is one spot for 360 IHD (ischemic heart disease) patients per year, and 33,04,474 more spaces were needed every year. Financial constraints and lack of patient referrals were the main barriers to the CR program. It was concluded from the survey that the CR program is most needed in India, particularly the northern region (40).

The rationale of Yoga as CR alternative

There are enough valid reasons that make Yoga a desirable option for CR in India over the standard CR program. Some of the rationales are listed below:

1. In India, Yoga is more accepted than any other form of physical activity and hence can be very well offered as a replacement for the CR program.
2. Yoga does not need costly equipment of comprehensive CR; only a properly trained yoga instructor is needed.
3. Ample numbers of Yoga schools are available in India with quality instructors.
4. Yoga can be easily practised at home. Tele-Yoga protocol has been developed looking into feasibility, efficacy and safety (41). A more extensive study is going on to look further into the role of Tele-Yoga (42).
5. The last decade has seen the resurgence of Yoga in India and is likely to gain much more interest at the community level in coming time. Hence, this acceptance of Yoga should be exploited in the health care system.
6. The government is also promoting Yoga in India, and yoga-based programs are being funded; hence Yoga can be integrated into the health care system at every level and with much wider coverage.
7. Yoga is not just a physical activity; it has many added benefits on mind, body, and emotions, helps in stress management and supports overall well-being. Considering high incidence of stress, depression, and anxiety in cardiac patients, Yoga is an excellent choice as a whole package of management strategy.
8. Yoga has various *Asanas*, equivalent as low to high-intensity physical activity. *Pranayama* is low intensity, *Vinyasa yoga* is medium intensity, and *Surya Namaskar* in high speed is equivalent to high-intensity exercise (43). Hence, Yoga sessions could be planned according to the patient's needs.

Barriers to Yoga and Physical activity in India

Though there is considerable evidence about the benefits of physical activity in risk factor reduction and secondary prevention in CAD patients, Yoga is not in common practice at community levels or among CAD patients. Reasons given by patients include lack of time, family responsibilities, financial issues, and ignorance to adopt a heart-healthy lifestyle. These factors act as barriers in adapting Yoga. A study reported that less than 50% of patients were aware of cardiac risk factors, and physicians instructed only 25% of these subjects about heart-healthy lifestyle (44). It indicates that both patients and health care persons are responsible for poor awareness. It is of utmost need that an awareness program about cardiac health improvement through Yoga must be augmented both in clinical settings and at a community level. Awareness about risk factors and the benefits of preventive measures will make people to adopt a healthy lifestyle (Figure 1). It is very encouraging that Yoga has been included in the curriculum of many schools. This will be helpful in reducing cardiovascular disease burden in future. In the health care system, Yoga instructors should be appointed. A recent survey reports that patients are willing to accept Yoga as alternative therapy for their neurological and cardiac disorders; it is the responsibility of health care policymakers to include Yoga in the health management system (45). Individual patient-need based Yoga module was developed for post-myocardial left ventricular dysfunction and has been accepted. This module should be validated in extensive studies so that it can be integrated with heart failure care (46).

Yoga Forms Practiced in India

India is the birthplace of Yoga, where many forms of Yoga have been practiced for centuries. Nowadays, the public definition of Yoga is limited only to physical aspect, which is *Asana*. But

there is a lack of awareness about the many uncovered levels of Yoga that saints, scholars, and yogis practice. In recent years, a holistic perspective of Yoga has been developed especially in the field of health management. It is not just the need of the hour but also necessary for the development of the holistic health of every individual. There are multiple forms of Yoga described in ancient and modern scriptures. Some of them are summarized below.

- **Ashtanga yoga:** *Mahirshi Patanjali* has discussed in *Patanjali Yoga Sutra* about the *Ashtanga yoga*. It is considered about 5000 years old and has eight limbs which are *Yama (External discipline)*, *Niyama (Internal discipline)*, *Asana (Physical postures)*, *Pranayama (Breathing Practices)*, *Pratyahara (Withdrawl of the senses)*, *Dharana (Concentration)*, *Dhyana (Meditation)*, and *Samadhi (Enlightenment)*. Long-term practice of *Ashtanga yoga* decreases glucose metabolism and has a beneficial role in mental health disorders (47).
- **Hath yoga:** *Hath yoga* includes mainly yogic *asanas*, six cleansing practices, *pranayama*, *pratyahara*, *mudras*, *bandhas* and *Samadhi*. *Hath yoga* also improves HRV parameters in *Hath Yoga* practitioners (48). In a study for improving cardiovascular health, metabolic and heart rate response were measured following *hath yoga* in 26 women but effect was less (49). *Hath yoga* clears anxiety and stress, improves executive function in diabetes (50).
- **Jnana yoga:** It mainly emphasizes wisdom yoga. The ultimate aim of *Jnana yoga* is to liberate oneself from the materialistic world and unite the soul with super consciousness. This Yoga has not been explored in CVDs.
- **Mantra yoga:** *Mantra yoga* is another type that uses *mantras* to awaken the self and deepen meditative states. *Mantra* alone has not been found effective in reducing

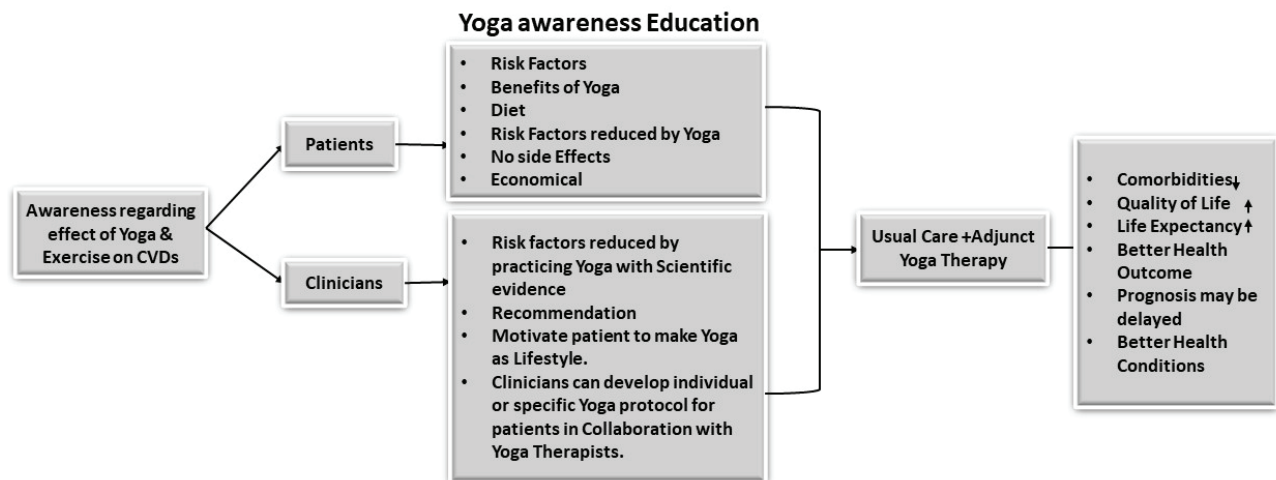


Figure 1: What is needed

stress, while a combination of *mantra* with *Ashtang Yoga* showed maximum benefit (51). Transcendental meditation is a specific form of *Mantra yoga*, and it has been found effective on immune cells such as B Lymphocytes, NK Cells, CD3+CD4-CD8+Cells those who practiced TM whereas CD3+CD4+CD8-Lymphocytes have showed low level (52).

- **Kundalini yoga:** It involves awakening of all the *chakras* (*Energy Point in our body*) and energy circuits in body by arousal of the dormant spiritual power at the base of the spine, called *Kundalini*. This form of Yoga is not suggested for ordinary practitioners, but only to those who are practising under the guidance of a guru who is an advanced practitioner (53).
- **Swara yoga:** *Swara yoga* is mainly related to the practice of breathing. According to the traditional *Swara yoga* concept, the airflow through the right nostril and *Pingalawara* is activatory, whereas the flow through left nostril and *Idaswara* is relaxatory in nature. Some breathing techniques are associated with an increase in heart rate and blood pressure, while some are related to reduction of these (54).
- **Raja yoga:** It involves a comprehensive program involving eight stages of yoga practice collectively to refine human behaviour and personality. It is reported that there is a parasympathetic predominance in those who practice *Raja yoga* (55).

Role of Various yogic practices in hypertension, arrhythmia, and CAD

While practicing Yoga, the practitioner breathes consciously and deeply, synchronizing with the body movements. It helps in controlling blood pressure, reduces stress and anxiety. Yoga in patients with arterial hypertension was found to be effective and safe. So, Yoga can be recommended as a complement to medication for the reduction of blood pressure. Several yogic practices (*Vyaghraasana*, *Virbhadrasana*, *Paschimottanasana*, *Setubandhsarvangasana*, *Suptaparivartanasana*, Mountain flow, and Half sun salutation), some breathing practices (*Nadisodhan*, *Anulom-Vilom*, and *Ujjayi*), and a few deep-relaxation techniques are beneficial in lowering hypertension. *Shavasana* also has been found effective in hypertension (56). Yogic interventions such as *Nadisodhan* and *Yoga nidra* are very effective in cardiac arrhythmia. *Nadisodhan* directly stabilizes the fundamental rhythmic cycle of the cardiorespiratory system, while *Yoga nidra* acts centrally upon the hypothalamus, influencing the influx of stressful stimuli on the heart by sympathetic nerves (57). Yogic practices like *Tadasana*, *Ardhmatsyendrasana*, *Bhujangasana*, *Dhanurasana*, *Uttanpadasana*, *Merudandasana*, *Setubandhasana*, *Gomukhasana*, and *Shavasana*, some breathing techniques like *Nadisodhan*, *Shitali*, *Sheetkari*, and more, a few relaxation techniques like DRT (Deep Relaxation Techniques), and *Yoga nidra* are beneficial in improving the quality of life and also enhancing cardiac health (58).

Safety Aspects of Yoga

Irrespective of so many benefits, Yoga also has many adverse events especially when an individual practices without proper guidance, instruction and when extreme forms are practiced without guidance. The most important part of Yogic practice is choosing the right form and tailoring it to individual needs and limitations, this can be recommended by experienced and certified Yoga trainer. A Yoga trainer examines the patients need, health history, medication history, and may collaborate with patient's clinician to design a specific Yogic protocol. In coronary artery disease, Yoga practice should be suggested according to the clinical profile of the patient. Intense yogic practices, forward bending *asanas* and inverted postures should not be practiced by cardiac patients. Despite many limitations, most studies assessing the safety of Yoga have demonstrated very low rates of adverse events (59). In 2015, a meta-analysis of 94 randomized control trials concluded that Yoga was not associated with a significant excess of intervention-related, non-serious, or serious adverse events, when compared with usual care or exercise (60).

Conclusion

Yoga is an integral part of traditional Indian philosophy and lifestyle. In context of Ancient Yogic literature, yogis or the advanced Yoga practitioners lived a hundred years and Yoga has much potential in providing better health and well-being. Yet, in studies done on coronary patients, results are inconsistent. However, it is of significance to note that these studies were of small scale, with few subjects, and short duration of Yoga intervention. Also, many studies were heterogeneous and have used low-intensity *Asana*. To correct altered cellular milieu, one needs to practice Yoga for a longer duration and with higher intensity. Hence to explore the full benefits of Yoga in real clinical practice, studies with Yoga practice for a longer duration in a larger sample size are warranted.

Authors' contribution

- SK: The author has written the whole manuscript in guidance and suggestions of other authors
 ND: The corresponding author has designed the structure of the review
 MR: The author has worked on grammatical and writing style of manuscript
 RK: The author has worked on findings related to Yoga
 GS: The author has worked on findings related to physical exercise.

Source of funding

There is no funding provided from any agency.

Conflict of interest

There is no conflict of Interest among authors.

Received Date: 31-03-22; Revised Date: 02-06-22

Accepted Date: 05-06-22

References

- World Health Organization. Global status report on noncommunicable diseases 2014. World Health Organization; 2014.
- Cardiovascular Diseases WHO, https://www.google.com/search?q=who+current+death+rate+due+to+cardiovascular+disease&rlz=1C1CHBF_enIN1009IN1009&oq=who+current+death+rate+due+to+cardiovascular+disease&aqs=chrome..69i57j33i160l2.225170j7&sourceid=chrome&ie=UTF-8, [Accessed on 29 June 2022]
- Agency for Healthcare Research and Quality. Medical expenditure panel survey (MEPS): Household component summary tables: Medical conditions, United States, 1996–2015. Agency for Healthcare Research and Quality website; 2020. <https://meps.ahrq.gov/mepstrends/hc_cond/>
- Virani SS, Alonso A, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Chang AR, Cheng S, Delling FN, Djousse LE. On behalf of the AHAC on E and PS, Association. C and SSS. Heart disease and stroke statistics-2020 update: a report from the American heart association. *Circulation*. 2020;141:e1–45.
- Pullen PR, Nagamia SH, Mehta PK, Thompson WR, Benardot D, Hammoud R, Parrott JM, Sola S, Khan BV. Effects of yoga on inflammation and exercise capacity in patients with chronic heart failure. *Journal of cardiac failure*. 2008 Jun 1;14(5):407–13.
- Dada R, Basant Kumar S, Chawla B, Bisht S, Khan S. Oxidative stress induced damage to paternal genome and impact of meditation and yoga-can it reduce incidence of childhood cancer? *Asian Pacific Journal of Cancer Prevention*. 2016 Sep 1;17(9):4517–25.
- Sharma M, Ganguly NK. Premature coronary artery disease in Indians and its associated risk factors. *Vascular health and risk management*. 2005 Sep;1(3):217.
- Patel C. 12-month follow-up of yoga and bio-feedback in the management of hypertension. *The Lancet*. 1975 Jan 11;305(7898):62–4.
- Supriya R, Yu AP, Lee PH, Lai CW, Cheng KK, Yau SY, Chan LW, Yung BY, Siu PM. Yoga training modulates adipokines in adults with high-normal blood pressure and metabolic syndrome. *Scandinavian journal of medicine & science in sports*. 2018 Mar;28(3):1130–8.
- Hadaye RS, Shastri S, Salagre S. Effect of yoga intervention in the management of hypertension: A preventive trial. *International Journal of Preventive Medicine*. 2021;12.
- Park SH, Han KS. Blood pressure response to meditation and yoga: a systematic review and meta-analysis. *The Journal of Alternative and Complementary Medicine*. 2017 Sep 1;23(9):685–95.
- Khandekar JS, Vasavi VL, Singh VP, Samuel SR, Sudhan SG, Khandelwal B. Effect of Yoga on Blood Pressure in Prehypertension: A Systematic Review and Meta-Analysis. *The Scientific World Journal*. 2021 Jan 1;2021.
- Penrod NM, Moore JH. Antihypertensive effects of yoga in a general patient population: real-world evidence from electronic health records, a retrospective case-control study. *BMC Public Health*. 2022 Dec;22(1):1–9.
- Sivasankaran S, Pollard-Quintner S, Sachdeva R, Pugada J, Hoq SM, Zarich SW. The effect of a six-week program of yoga and meditation on brachial artery reactivity: Do psychosocial interventions affect vascular tone?. *Clinical Cardiology: An International Indexed and Peer-Reviewed Journal for Advances in the Treatment of Cardiovascular Disease*. 2006 Sep;29(9):393–8.
- Saely C, Zanolin D, Vonbank A, Leihnerer A, Drexel H. Diabetes awareness among coronary disease patients differs significantly between men and women. *Atherosclerosis*. 2016 Sep 1;252:e146–7.
- Mody BS. Acute effects of Surya Namaskar on the cardiovascular & metabolic system. *Journal of bodywork and movement therapies*. 2011 Jul 1;15(3):343–7.
- Thind H, Lantini R, Balletto BL, Donahue ML, Salmoirago-Blotcher E, Bock BC, Scott-Sheldon LA. The effects of yoga among adults with type 2 diabetes: A systematic review and meta-analysis. *Preventive medicine*. 2017 Dec 1;105:116–26.
- Nagarathna R, Tyagi R, Kaur G, Vendan V, Acharya IN, Anand A, Singh A, Nagendra HR. Efficacy of a validated yoga protocol on dyslipidemia in diabetes patients: NMB-2017 India trial. *Medicines*. 2019 Dec;6(4):100.
- Nagarathna R, Kumar S, Anand A, Acharya IN, Singh AK, Patil SS, Latha RH, Datey P, Nagendra HR. Effectiveness of Yoga Lifestyle on Lipid Metabolism in a Vulnerable Population—A Community Based Multicenter Randomized Controlled Trial. *Medicines*. 2021 Jul;8(7):37.
- Rshikesan PB, Pailoor Subramanya RN. Yoga practice for reducing the male obesity and weight related psychological difficulties-A randomized controlled trial. *Journal of clinical and diagnostic research: JCDR*. 2016 Nov;10(11):OC22.
- Patil SG, Patil SS, Aithala MR, Das KK. Comparison of yoga and walking-exercise on cardiac time intervals as a measure of cardiac function in elderly with increased pulse pressure. *Indian heart journal*. 2017 Jul 1;69(4):485–90.
- Lauche R, Langhorst J, Lee MS, Dobos G, Cramer H. A systematic review and meta-analysis on the effects of yoga on weight-related outcomes. *Preventive medicine*. 2016 Jun 1;87:213–32.
- Dhananjai S, Tiwari S, Dutt K, Kumar R. Reducing psychological distress and obesity through Yoga practice. *International journal of yoga*. 2013 Jan;6(1):66.
- Sharma KNS, Pailoor S, Choudhary NR, Bhat P, Shrestha S. Integrated Yoga Practice in Cardiac Rehabilitation Program: A Randomized Control Trial. *J Altern Complement Med*. 2020 Oct;26(10):918–927. <https://doi.org/10.1089/acm.2019.0250>. Epub 2020 Jun 29. PMID: 32608989.
- Krishna BH, Pal P, Pal GK, Balachander J, Jayasettiaseelon E, Sreekanth Y, Sridhar MG, Gaur GS. A randomized controlled trial to study the effect of yoga therapy on cardiac function and N terminal pro BNP in heart failure. *Integrative medicine insights*. 2014 Jan;9:IMI-S13939.
- Manchanda SC, Narang R, Reddy KS, Sachdeva U, Prabhakaran D, Dharmanand S, Rajani M, Bijlani R. Retardation of coronary atherosclerosis with yoga lifestyle intervention. *The Journal of the Association of Physicians of India*. 2000 Jul 1;48(7):687–94.
- Yogendra J, Yogendra HJ, Ambardekar S, Lele RD, Shetty S, Dave M, Husein N. Beneficial effects of yoga lifestyle on reversibility of ischaemic heart disease: caring heart project of International Board of Yoga. *JAPI*. 2004 Apr;52:283–9.
- Li J, Gao X, Hao X, Kantas D, Mohamed EA, Zheng X, Xu H, Zhang L. Yoga for secondary prevention of coronary heart disease: A systematic review and meta-analysis. *Complementary Therapies in Medicine*. 2021 Mar 1;57:102643.
- Bruce C, Achan V, Rathore S. Yoga-Based Cardiac Rehabilitation: Current Perspectives from Randomized Controlled Trials in Coronary Artery Disease. *Vascular Health and Risk Management*. 2021;17:779.
- Prabhakaran D, Chandrasekaran AM, Singh K, Mohan B, Chattopadhyay K, Chadha DS, Negi PC, Bhat P, Sadananda KS, Ajay VS, Singh K. Yoga-based cardiac rehabilitation after acute myocardial infarction: a randomized trial. *Journal of the American College of Cardiology*. 2020 Apr 7;75(13):1551–61.
- Walter AA, Adams EV, Van Puymbroeck M, Crowe BM, Urrea-Mendoza E, Hawkins BL, Sharp J, Woschkolup K, Revilla FJ, Schmid AA. Changes in nonmotor symptoms following an 8-week yoga intervention for people with Parkinson's disease. *International journal of yoga therapy*. 2019 Nov;29(1):91–9.
- Grabara M, Nowak Z, Nowak A. Effects of hatha yoga on cardiac hemodynamic parameters and physical capacity in cardiac rehabilitation patients. *Journal of Cardiopulmonary Rehabilitation and Prevention*. 2020 Jul 1;40(4):263–7.
- Tillin T, Tuson C, Sowa B, Chattopadhyay K, Sattar N, Welsh P, Roberts I, Ebrahim S, Kinra S, Hughes A, Chaturvedi N. Yoga and Cardiovascular Health Trial (YACHT): a UK-based randomised mechanistic study of a yoga intervention plus usual care versus usual care alone following an acute coronary event. *BMJ open*. 2019 Nov 1;9(11):e030119.

34. Gupte RS, Vijay V, Marks B, Levine RJ, Sabbah HN, Wolin MS, Recchia FA, Gupte SA. Upregulation of glucose-6-phosphate dehydrogenase and NAD (P) H oxidase activity increases oxidative stress in failing human heart. *Journal of cardiac failure*. 2007 Aug 1;13(6):497–506.
35. Morgan N, Irwin MR, Chung M, Wang C. The effects of mind-body therapies on the immune system: meta-analysis. *PloS one*. 2014 Jul 2;9(7):e100903.
36. Chen PJ, Yang L, Chou CC, Li CC, Chang YC, Liaw JJ. Effects of prenatal yoga on women's stress and immune function across pregnancy: A randomized controlled trial. *Complementary therapies in medicine*. 2017 Apr 1;31:109–17.
37. Ungaro F, Rubbino F, Danese S, D'Alessio S. Actors and factors in the resolution of intestinal inflammation: lipid mediators as a new approach to therapy in inflammatory bowel diseases. *Frontiers in immunology*. 2017 Oct 23;8:1331.
38. Kaliman P, Alvarez-Lopez MJ, Cosin-Tomás M, Rosenkranz MA, Lutz A, Davidson RJ. Rapid changes in histone deacetylases and inflammatory gene expression in expert meditators. *Psychoneuroendocrinology*. 2014 Feb 1;40:96–107.
39. Duraimani S, Schneider RH, Randall OS, Nidich SI, Xu S, Ketete M, Rainforth MA, Gaylord-King C, Salerno JW, Fagan J. Effects of lifestyle modification on telomerase gene expression in hypertensive patients: a pilot trial of stress reduction and health education programs in African Americans. *PloS one*. 2015 Nov 16;10(11):e0142689.
40. Strömberg A, Thylén I, Orwelius L, Klompstra L, Jaarsma T. Tele-Yoga in Long Term Illness—Protocol for a Randomised Controlled Trial Including a Process Evaluation and Results from a Pilot Study. *International Journal of Environmental Research and Public Health*. 2021 Jan;18(21):11343.
41. Selman L, McDermott K, Donesky D, Citron T, Howie-Esquivel J. Appropriateness and acceptability of a Tele-Yoga intervention for people with heart failure and chronic obstructive pulmonary disease: qualitative findings from a controlled pilot study. *BMC complementary and alternative medicine*. 2015 Dec;15(1):1–3.
42. Basu-Ray I. A mechanistic model for yoga as a preventive and therapeutic modality. *International Journal of Yoga*. 2021 May;14(2):152.
43. Dahiya N, Sharma V, Kumar B, Thakur JS, Kumar S. Awareness and adherence to primary and primordial preventive measures among family members of patients with myocardial infarction—the unmet need for a “Preventive Clinic”. *Indian Heart Journal*. 2020 Sep 1;72(5):454–8.
44. Sharma G, Gujral JS, Agarwal A, Jat M, Mohanty S, Pandey RM. Exploring knowledge, attitude and practice regarding yoga among patients attending cardiology and neurology clinics in a tertiary care hospital in northern India. *National Medical Journal of India*. 2021 Jul 1;34(4).
45. Sharma S, Pailoor S, Ram NC, Shrestha S. Development of a yoga module targeting cardiovascular health for patients with post-myocardial left ventricular dysfunction in India. *Complementary Therapies In Medicine*. 2019 Feb 1;42:170–7.
46. Jarry JL, Chang FM, La Civita L. Ashtanga yoga for psychological well-being: initial effectiveness study. *Mindfulness*. 2017 Oct;8(5):1269–79.
47. Balakrishnan B, Metri KG, Day J, Ganesan M. Long-Term Effects of Hatha Yoga on Heart Rate Variability In Healthy Practitioners: Potential Benefits For Cardiovascular Risk Reduction. *Alternative therapies in health and medicine*. 2021 Aug 30.
48. Clay CC, Lloyd LK, Walker JL, Sharp KR, Pankey RB. The metabolic cost of hatha yoga. *Journal of Strength and Conditioning Research*. 2005 Aug 1;19(3):604.
49. Vizcaino M. Hatha yoga practice for type 2 diabetes mellitus patients: a pilot study. *International journal of yoga therapy*. 2013 Jan 1;23(2):59–65.
50. Matko K, Sedlmeier P, Bringmann HC. Differential Effects of Ethical Education, Physical Hatha Yoga, and Mantra Meditation on Well-Being and Stress in Healthy Participants—An Experimental Single-Case Study. *Frontiers in Psychology*. 2021;12.
51. Infante JR, Peran F, Rayo JI, Serrano J, Domínguez ML, Garcia L, Duran C, Roldan A. Levels of immune cells in transcendental meditation practitioners. *International journal of yoga*. 2014 Jul;7(2):147.
52. Jung CG. *The psychology of kundalini yoga*. Princeton University Press; 2012 Jan 12.
53. Bhavanani AB, Ramanathan M, Balaji R, Pushpa D. Differential effects of uninostril and alternate nostril pranayamas on cardiovascular parameters and reaction time. *International journal of yoga*. 2014 Jan;7(1):60.
54. Mandape A, Bharshankar J, Phatak M. Effect of Raja Yoga meditation on the lipid profile of healthy adults in Central India. *Journal of Medical Sciences and Health*. 2015 Jan;1(1):10–3.
55. Sundar S, Agrawal SK, Singh VP, Bhattacharya SK, Udupa KN, Vaish SK. Role of yoga in management of essential hypertension. *Acta cardiologica*. 1984 Jan 1;39(3):203–8.
56. Saraswati S. *Yoga and cardiovascular management*. Bihar School of Yoga; 1982.
57. Ministry of Ayush, *Yoga for Cardiac Health* from <<https://yoga.ayush.gov.in>> [Accessed 4 March 2022]
58. Cramer H, Ward L, Saper R, Fishbein D, Dobos G, Lauche R. The safety of yoga: a systematic review and meta-analysis of randomized controlled trials. *American Journal of Epidemiology*. 2015 Aug 15;182(4):281–93.
59. Szabo-Reed A, Clutton J, White S, Van Sciver A, White D, Morris J, Martin L, Lepping R, Shaw A, Puchalt JP, Montgomery R. COMBINED Exercise Trial (COMET) to improve cognition in older adults: Rationale and methods. *Contemporary Clinical Trials*. 2022 May 27:106805.