

Indranill Basu-Ray · Darshan Mehta *Editors*

## The Principles and Practice of Yoga in Cardiovascular Medicine

This is the world's first reference book covering the role of Yoga in Cardiovascular Diseases. It details epidemiology, physiology, pathology, prevention, and management of cardiovascular diseases based on the current scientific understanding of Yoga. Seventy-five experts from four continents, including the most notable names, contributed to this work to create the world's first comprehensive reference literature on Yoga in cardiovascular medicine.

The chapters cover information related to Yoga, both as prevention and therapy, including coronary artery disease, heart failure, and arrhythmias. In addition, important cardiovascular topics like obesity and diabetes mellitus are also included.

A special chapter covers the role of Yoga in the prevention of cardiovascular complications in COVID-19 patients.

Basu-Ray · Mehta *Eds.*

# The Principles and Practice of Yoga in Cardiovascular Medicine



The Principles and Practice of Yoga in  
Cardiovascular Medicine

Indranill Basu-Ray  
Darshan Mehta  
*Editors*

ISBN 978-981-16-6912-5



► [springer.com](https://www.springer.com)

 Springer

---

# The Principles and Practice of Yoga in Cardiovascular Medicine

---

Indranill Basu-Ray  
Editor-in-Chief

Darshan Mehta  
Editor

# The Principles and Practice of Yoga in Cardiovascular Medicine

*Editor-in-chief*

Indranill Basu-Ray  
Cardiologist & Cardiac  
Electrophysiologist, Director of  
Cardiovascular Research  
Memphis VA Medical Center  
Memphis, TN, USA

Adjunct Professor of Public Health: The  
University of Memphis  
Memphis, TN, USA

Adjunct Professor of Cardiology  
& Head of Integrative Cardiology  
All India Institute of Medical Sciences  
Rishikesh, UK, India

*Editor*

Darshan Mehta  
Medical Director, Benson-Henry  
Institute for Mind Body Medicine &  
Director, Office for Well-Being, Center  
for Faculty Development  
Massachusetts General Hospital  
Boston, MA, USA

Education Director, Osher Center for  
Integrative Medicine  
Harvard Medical School and Brigham  
and Women's Hospital  
Boston, MA, USA

Assistant Professor of Medicine  
Harvard Medical School  
Boston, MA, USA

ISBN 978-981-16-6912-5      ISBN 978-981-16-6913-2 (eBook)

<https://doi.org/10.1007/978-981-16-6913-2>

© Springer Nature Singapore Pte Ltd. 2022

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd. The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

*To my wife, Julie who made it all possible.*

*—Dr. Indranill Basu-Ray*

*This book is dedicated to my daughter, Asha, whose love and laughter continues to light my life with hope and joy.*

*—Dr. Darshan Mehta*

---

## Foreword

Spending over six decades in learning, teaching, and mentoring studies in Indian philosophy, I was always intrigued by the almost magical powers that yoga is believed to confer. It has long been noted that yoga slows the aging process making it possible for a 90-year-old gentleman to look and function as if he were decades younger. It changes the brain to make it more powerful memory-wise. People with extended meditation practice are rarely known to be hypertensive. Such claims have been made from time to time down through the ages, often by people with little or no training in modern biology or medicine. Thus, it is impossible to know how many of these are real facts or just hyperbole by enamored practitioners of yoga worldwide.

Dr. Indranill Basu-Ray has spent most of his professional career as a cardiologist with research in yoga and heart disease. He is the author of the first guidelines on the role of Meditation in Cardiovascular disease written on behalf of the American Heart Association. One of the modern evils of civilization has been the epidemic spread of dangerous non-communicable diseases such as heart disease which is rampant as one out of every four people in this world is afflicted. Millions are suffering and maimed with it from all over the world, and it continues to kill twice the number of people than cancer which is the second largest killer of mankind. Modern research in the frontiers of medicine has revealed that the cause of heart disease can be traced to inflammation in our blood vessels due to the stress of day-to-day living. Blood vessels are the source of nutrition to the vital organs, including the heart, the brain, and the kidneys. Inflammation in these blood vessels and the resulting damages to these organs induces tremendous mortality and morbidity.

Dr. Basu Ray has been in the frontline of research into the role of yoga and heart disease. He had developed an interest in meditation since childhood. Formally trained in Kriya Yoga at a young age, along with following the strict yogic lifestyle, created an urge to understand the science behind such processes. Encouraged by his mentor Swami Hariharananda Giri, a self-realized yoga master, Dr. Basu-Ray decided to study cardiology. His guru's wish was to understand, unravel, and bring the biology behind yoga and meditation to the common man. Self-practice of meditation for hours deepened his understanding of the physical processes involved in yoga and meditation while studying the latest research in the field further helped cement an understanding of the process. He has passed on this knowledge to physicians, scientists, researchers, and yoga enthusiasts while trying to infuse a desire to understand

and practice yoga scientifically rather than being a blind believer. The book is part of that effort to present scientific research on yoga's role in the prevention and treatment of cardiovascular diseases.

This book talks about disease prevention and healing using yoga. Yoga has been a subject of extensive research in the last decade, which has proven its usefulness. Moreover, it is universal as both the poor and the rich can be benefitted. One does not need costly equipment or a loaded purse. Patience and determination to have daily practice are the only requirements. This book essentially outlines the updated research in every aspect of cardiovascular disease for the practitioner to use his art and science of healing. It also provides leads to researchers on lines that would need further investigation. Around seventy-five of the world's top physicians, scientists, and researchers have contributed to making this book the first complete encyclopedia of yoga for cardiovascular diseases, indeed a remarkable achievement.

Over the last few decades, scientific evidence of yoga and its effect has been found through genetic, epigenetic, molecular, and cellular studies. It is apparent how aberrant pathology created by stress results in heart disease and how yoga can reverse it to normal physiology restoring a harmonious balance. Despite its popularity the world over, yoga is entangled in the quagmire of unscientific deliberations, metaphysical debates, and unwanted wrangling by people with an inadequate scientific background. This situation is perpetuated by practitioners who claim knowledge about yoga by becoming "posture experts" but are wholly divorced from yoga's scientific rationale.

While yoga as a series of postures has become popular throughout the world, and indeed now we have a World Yoga Day, it is important to remember that though all these postures are useful, yoga is something deeper than only a physical exercise. It affects the body, the emotions, and the mind, all three of which need to be functioning harmoniously. This book helps us understand the science behind the use of yoga as a preventive and therapeutic modality and is a valuable addition to the growing volume of literature on various aspects of yoga. I commend Dr. Basu Ray for his pioneering work in bringing together so many expert views on this fascinating subject.

2nd January 2022

Dr. Karan Singh  
Former Minister of Health and Family Planning,  
Government of India  
Former Chancellor, Jawaharlal Nehru University &  
Benares Hindu University

Padma Vibhusan

---

## Foreword

One of the present problems in today's society, which is also unfortunately reflected in scientific inquiry in medicine, is materialism. This philosophy automatically assumes that most events on this planet can be analyzed and expressed within the restricted lens of materialism. Materialism holds that there must be a physical explanation for every phenomenon. However, Indian sages from millennia taught that most phenomena have an extra materialistic basis that cannot always be explained by scientific determinism or mundane day-to-day materialistic thought. Though not patent with everyday science, this idea has enabled many scientific thinkers and philosophers to think "out of the box." They were able to conjure theories that were initially revolted as outlandish as they were totally against established concepts but accepted subsequently. A case in point is that many such "outrageous conclusions" such as "quantum entanglement" that have been accepted today in quantum physics, continues to defy established materialistic view.

Materialism left out the mind-body connection. Yoga which includes meditation is one such entity. The "mind" is not material. Yet yoga claims that mind and body are a single element with two entangled parts—the brain and the body. Moreover, there is a constant connect between them that ensures mind dictating every aspect of the body including its physiological constitution and genetic configuration. Ostensibly such a phantasmal claim made in a prehistoric treatise by Maharishi Patanjali was not precisely digestible for consumption to modern science and their torch bearers. Thus, relegated to just another physical exercise, yoga languished in this century and became restricted to yoga studios. Not particularly academically bright, but suave entrepreneurs made millions gaining from its popularity. Yoga, unfortunately, was thus hidden from the discerning eyes of scientists who would have subjected it to dissection using a standard scientific protocol to determine its true nature and effects on human physiology. Meanwhile, the already soaring popularity got skyrocketed when at the behest of India's prime minister, Mr. Narendra Modi, the United Nations accepted June 21 as the International Day of Yoga. The time-honored road to enlightenment devised by Hindu sages meanwhile soared to an \$80 billion physical fitness business worldwide with over 50 million practitioners in the US alone and six times that number in the rest of the world.

This explosion in yoga's popularity as a fitness regime generated interest in the academic community to study yoga's effects on health and disease. In India, we have been doing clinical trials for over four decades on yoga's role in various diseases. The first scientific paper was published way back in



Circulation in the December of 1961. In 1986 in BMJ. The mentality to scientifically interrogate yoga started relatively late in the West but was a welcome change. Many researchers working at various universities started studying yoga's clinical effects in the last few decades. Numerous institutions like MD Anderson started implementing yoga protocols in their treatment strategies. Cardiovascular disease remains the largest killer on this planet. There is some evidence that multiple cardiac risk factors, including hypertension, diabetes mellitus, and hyperlipidemia, benefit from yoga, including meditation. Stress is now considered the predominant underlying cause for many non-communicable diseases responsible for 70% of mortality on earth. Accumulated evidence in the last decade point to the genetic and endocrinal changes that perpetuate inflammation in blood vessels leading to heart attack, stroke, or peripheral arterial disease. The origins of these have been deciphered to be induced by a pathophysiological reaction to stress. Though not any particular type of stress but all kinds, including the so-called mundane ones that we have to navigate in our daily existence. Yoga has been evidenced to reverse this aberrant pathophysiology. This book attempts to present the physiological changes including clinical evidence of yoga's role in cardiovascular diseases. It is written by over 75 eminent authors from multiple disciplines. This, to my knowledge, is one of the first attempts to provide a detailed but updated account of the clinical validity of using yoga, both as preventive and therapeutic modalities for cardiovascular diseases. Cardiologists, psychiatrists, neurologists, and integrative medicine experts have contributed, putting in their years of expertise in this book.

Dr. Indranill Basu-Ray, whose brainchild is this project, has been known to me for many years. Besides being an eminent cardiologist with research in yoga, Dr. Basu Ray is one of those few people with experiential knowledge of the system. He has been practicing yoga which includes deep meditation, since the age of six. Trained by various Himalayan masters, he has been a practitioner of Kriya Yoga. He was initiated into kriya yoga by Swami Hariharananda Giri, a disciple of Sri Yuktेश्वar Giri and the brother disciple of Paramhansa Yogananda of fame through his book "Autobiography of a Yogi." I mention this not for a historical reason, but this has scientific ramifications in studying and interpreting yoga's overall effect. It is imperative to understand that yoga is not a theoretical construct. Nor is it a practical protocol to develop physical fitness alone. Postural yoga inundated with an emphasis on physical prowess called Hatha yoga also is meant for one's evolution through mastery over the modifications of the mind. Sage Patanjali, in his yoga sutras, talks about how to use these physical practices also to achieve "enlightenment" referred to as merging of individual consciousness with the cosmic consciousness. It is a discipline couched in metaphysical constructs that is mostly inaccessible to anybody other than a practitioner guided by an experienced master. It is an experience-based science that highlights personal development through both mental and physical discipline. The meditation part of the construct, it may be remembered, is that it yields the major beneficial effects of rewiring the constructs in the psyche and the

brain. Meditative practices induce changes that have the potential to reverse the stress-related inflammation that is known to be responsible for heart diseases. Surprisingly, this deeper understanding is lacking in today's popular way of practicing yoga postures. Although these physical postures performed like exercises are clearly beneficial for health, fitness, and a sense of well-being, the programs taught today under the name of physical yoga typically bear little resemblance to the tradition whose name they use. Thus, testing yoga protocols devoid of its valid construct though helpful, will never reveal the true extent of yoga's prowess to decrease aging, prevent heart diseases, or root out anxiety and depression. Since childhood, Dr. Basu Ray, being trained in the yogic system and philosophy, is best suited to understand real yoga's nuances outlined by Patanjali in his Yoga Sutra and many other authorities. In principle, this entails a silent and internalized journey that proceeds, independent of external input, through defined and progressive phases of relaxation, interiorization, and expansion. It begins with a withdrawal of the senses from their gross level of functioning termed *pratyahara* and proceeds through a stage of mindfulness called *Dharana* followed by deep meditation or *dhyana*, which results in successive levels of settled mental absorption termed *samadhi*.

I commend the editors and the authors for taking this arduous task of bringing to light the yoga's benefits, as evidenced by clinical studies. This endeavor, I am confident, will entice many clinicians and researchers to take-up yoga research. Moreover, it will entail millions who practice yoga to be assured that their health is protected by one of the best inventions in this universe ever discovered by mankind.

1st January 2022  
Bengaluru, India

H. R Nagendra  
Chancellor,  
Swami Vivekananda Yoga  
Anusandhana Samsthana (a Deemed University),  
Prashanti Kutiram Vivekananda Road,  
Kalluballu Post, Jigani, Anekal, Bengaluru

Padma Shri

---

# Contents

## Part I Introduction

- 1 Cardiology: A Primer for the Uninitiated. . . . . 3**  
Indranill Basu-Ray and Dibbendhu Khanra
- 2 Addressing the Common Risk Factors for Reducing  
the Burden of Cardiovascular Diseases: The Impact of Yoga. . . 39**  
K. Srinath Reddy and Manu Raj Mathur
- 3 The Nature, Meaning, and Practice of Yoga:  
Traditional Base Meets Scientific Rigor . . . . . 45**  
Paul Dallaghan and Indranill Basu-Ray
- 4 Yoga in the Management of Cardiovascular Disease:  
A Brief Introduction . . . . . 55**  
Gregory Fricchione

## Part II Pathophysiology

- 5 Mechanistic Model for Yoga as a Therapeutic Modality in  
Cardiovascular Disease. . . . . 69**  
Indranill Basu-Ray
- 6 The Anatomical, Physiological and Neurochemical Correlates  
of Yoga . . . . . 81**  
Mrithunjay Rathore
- 7 Cardiovascular Influence of Yoga Assessed with  
Heart Rate Variability Measures. . . . . 89**  
Inbaraj Ganagarajan, Kaviraja Udupa, and T. N. Sathyaprabha
- 8 Mechanisms and Biomarkers to Understand Impacts  
of Yoga in Cardiovascular Diseases . . . . . 97**  
Chainika Khatana, Neeraj K. Saini, Priyanka Thakur,  
Reena V. Saini, and Adesh K. Saini
- 9 Stress and the Autonomic Nervous System:  
Implication of Yoga . . . . . 105**  
Kaviraja Udupa, Ananda Balayogi Bhavanani,  
and Meena Ramanathan

- 10 Neurobiological Effects of Yoga on Stress Reactivity. . . . . 117**  
Michaela C. Pascoe, David R. Thompson, and Chantal F. Ski
- 11 Mind and Cardiovascular Disease: Mechanism of Interrelationship. . . . . 123**  
Sanjay S. Phadke and Leena S. Phadke

### **Part III Imaging and Laboratory Techniques**

- 12 Next-Generation Techniques for Validating Yoga Effect on the Cardiovascular System . . . . . 137**  
Kochhar Kanwal Preet, Yadav Raj Kumar, Sunil, and Shweta Sharma
- 13 Yoga and Neuroimaging Current Status of Evidence . . . . . 151**  
Sumana Venugopal, Venkataram Shivakumar, Bharath Holla, Shivarama Varambally, and B. N. Gangadhar

### **Part IV Yoga for Various Cardiovascular Diseases**

- 14 Yoga: A Holistic Approach for Cardiac Arrhythmia . . . . . 161**  
Indranill Basu-Ray and Anindya Mukherjee
- 15 Cardiometabolic Syndrome and Effects of Yoga . . . . . 167**  
Sridip Chatterjee and Puneet Bhattacharya
- 16 Role of Yoga in Prevention and Management of Type 2 Diabetes Mellitus (T2DM) and Its Complications. . . . . 197**  
Kashinath Metri, R Nagaratna and Amit Singh
- 17 Yoga and Obesity. . . . . 205**  
Ravi Kant and Nisha Batra
- 18 Yoga for Dyslipidemia. . . . . 223**  
Jaideep Arya, Prashant Verma, Deepali Mathur, Rahul Tyagi, Viraj Pannu, and Akshay Anand
- 19 Yoga for Primary and Secondary Prevention of Coronary Heart Disease. . . . . 243**  
Subhash Chander Manchanda and Kushal Madan
- 20 Role of Yoga in Stroke Management: Current Evidence and Future Directions. . . . . 253**  
Nishitha Jasti, Ashok Vardhan Reddy, Kishore Kumar Ramakrishna, Hemant Bhargav, and Girish Baburao Kulkarni
- 21 Meditation and Yoga in the Treatment of Addictive Disorders . . . . . 267**  
Debesh Mallik, Tyree Dingle, and Sarah Bowen

<b>22</b>	<b>Yoga and Cardiovascular Disease Prevention in African Americans and Hispanics . . . . .</b>	<b>277</b>
	Keith C. Norris and Bettina M. Beech	
<b>23</b>	<b>Yoga in the Management of Arterial Hypertension . . . . .</b>	<b>285</b>
	Laura Tolbaños-Roche, Praseeda Menon, and Subodh Tiwari	
<b>24</b>	<b>Meditation in Prevention and Treatment of Cardiovascular Disease: An Evidence-Based Review . . . . .</b>	<b>303</b>
	Robert H. Schneider, Komal Marwaha, and John Salerno	
<b>25</b>	<b>Yoga for Heart Failure . . . . .</b>	<b>327</b>
	Paula R. Seffens (aka Pullen), Aneesha Thobani, William S. Seffens, Senait Asier, and Puja K. Mehta	
<b>26</b>	<b>Yoga for Mental Health and Comorbidities . . . . .</b>	<b>335</b>
	Praerna Hemant Bhargav, Hemant Bhargav, Rashmi Arsappa, and Shivarama Varambally	
<b>27</b>	<b>Role of Yoga and Meditation in Palliative Care . . . . .</b>	<b>345</b>
	Dibbendhu Khanra, Anindya Mukherjee, Shishir Soni, and Indranill Basu-Ray	
<b>28</b>	<b>Yoga-Based Cardiac Rehabilitation Program for Cardiovascular Health . . . . .</b>	<b>351</b>
	Ambalam M. Chandrasekaran, Dorairaj Prabhakaran, and Sanjay Kinra	
<b>29</b>	<b>Yoga as a Potential Intervention for Preventing Cardiac Complications in COVID-19: Augmenting Immuno-Modulation and Bolstering Mental Health . . . . .</b>	<b>367</b>
	Indranill Basu-Ray and Kashinath Metri	

## **Part V Appendix**

<b>30</b>	<b>Dinacharya the Daily Routine and Ritucharya the Seasonal Routine for Yogic Lifestyle . . . . .</b>	<b>383</b>
	Dilip Sarkar	
<b>31</b>	<b>Yogic Diet and its Anti-inflammatory Effect in Relation to CVD . . . . .</b>	<b>395</b>
	Kanwal Preet Kochhar, Sunil, Tamoghna Ghosh, and Jyoti Arora	
<b>32</b>	<b>Principles of Diet for a Yogic Lifestyle . . . . .</b>	<b>405</b>
	Gauri Junnarkar	

---

## About the Editors

**Indranill Basu-Ray, MBBS, MD (Med), DNB (Card), FACP, FACC** is a Cardiac Electrophysiologist and a Professor of Cardiology and Public Health, based in Memphis, TN, USA. He is the Founder Chairman of The American Academy of Yoga and Meditation. Dr. Basu-Ray went to medical school at the Nil Ratan Sircar Medical College in Kolkata, West Bengal, India. He has further trained in Cardiology and Interventional Cardiac Electrophysiology from Tulane University in New Orleans, LA, and Texas Heart Institute at the Baylor College of Medicine, Houston, TX. In addition, he trained in Cardiac Electrophysiology Research at the Massachusetts General Hospital, Harvard Medical School in Boston, MA. Dr. Basu Ray is an active researcher in cardiac electrophysiology and yoga and has numerous peer-reviewed research articles. In addition, he has contributed book chapters to multiple books in Cardiology and Medicine. He is the editor of *Clinical Cardiology*, a book for the medical curriculum for subspecialty training in cardiology with over forty authors contributing from worldwide. Dr. Basu-Ray has been a practicing yogi and started meditating at the age of six. He was initiated by Swami Hariharananda Giri, the brother disciple of Paramhansa Yogananda of the “Autobiography of a Yogi” fame. He has been practicing, teaching, and researching yoga and meditation for over three decades now. His research centers on the use of meditation and yoga in cardiovascular diseases. He wrote the American Heart Association’s scientific statement on using meditation to treat cardiovascular diseases. He is the founder chairman of the American Academy for Yoga and Meditation (AAYM). AAYM is an organization of physicians, scientists, and researchers who work on scientific validation of Yoga and Meditation and hold regular international conferences worldwide where the latest research is presented. He was the program director of the “World’s first conference on the role of Meditation in Cardiovascular Diseases” held at All India Institute of Medical Sciences, Rishikesh, UK, India. He also led the virtual conference—Yoga Conference USA 2021 held virtually with over a hundred speakers and fifty sessions. Dr. Basu-Ray played a pioneering role in developing multiple tools for atrial fibrillation and Ventricular Tachycardia ablation in humans today. He was involved in the initial proof of concept for cryotherapy and the laser balloon used for atrial fibrillation ablation. He contributed to the initial research of a new iteration of 3D mapping systems using multimodality imaging used for intracardiac mapping today. Dr. Basu-Ray performs complex ablations for Atrial Fibrillation and Ventricular Tachycardia. He also treats Heart failure with ICD’s, Cardiac

Resynchronization Devices, and S-ICD's. He also implants Pacemaker and leadless Pacemakers for bradyarrhythmia therapy. Dr. Basu Ray lives with his wife Julie and son Ishan in Memphis, TN, USA.

**Darshan Mehta, MD, MPH** is a Medical Director and a Director of Medical Education for the Benson-Henry Institute for Mind Body Medicine at Massachusetts General Hospital (BHI-MGH) and a Director of Education at the Osher Center for Integrative Medicine, Harvard Medical School and Brigham and Women's Hospital (OCIM). In addition, he is the MGH site director for the Practice of Medicine curriculum required of all first-year Harvard Medical School students, and leads their well-being curriculum. Dr. Mehta received his BA in Biology from Illinois Wesleyan University and an MD from the University of Texas-Southwestern Medical School. He completed his residency in internal medicine at the University of Illinois-Chicago Hospital. In 2008, he completed a clinical research fellowship in complementary and integrative medicine at the Harvard Medical School Osher Research Center, during which he received a Master of Public Health degree from the Harvard School of Public Health. His educational and research interests include curricular development in complementary and integrative medical therapies, mind/body educational interventions in health professions training, and promotion of professionalism in medical trainees. He directs medical student and resident rotational electives at BHI-MGH and the Osher Center. Dr. Mehta sees patients at both locations in a consultative role for use of complementary and integrative medical therapies, as well as mind/body interventions for stress management and stress reduction. Dr. Mehta is active in the Massachusetts Medical Society and is a member of the American College of Physicians. Dr. Mehta is board-certified through the American Board of Integrative Medicine and has completed professional training in mindfulness-based stress reduction at the University of Massachusetts Medical School. He serves on the leadership for the Academic Consortium for Integrative Medicine and Health and is on the Editorial Board for the Journal of Alternative and Complementary Medicine.