

# YOGA FOR CARDIOVASCULAR DISEASE AND REHABILITATION

Integrating Complementary  
Medicine into Cardiovascular Medicine



**Indranill Basu-Ray**



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# Dedications

This book is dedicated to the stalwarts who discovered yoga and practiced it to perfection and on whose shoulders we stand today:

**Maharishi Patanjali,  
Mahavatar Babaji,  
Adi Shankaracharya,  
Ramakrishna Paramhansa,  
Swami Vivekananda,  
Syamacharan Lahiri Mahasaya,  
Swami Yukeshwar Giri,  
Paramhansa Yogananda,  
Maharishi Aurobindo.**

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Without their support, gaining knowledge and practicing yoga and medicine together would not be possible.

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# Foreword

Cardiovascular disease remains the largest pandemic, killing both men and women throughout the world. One person dies every 33 s in the United States from cardiovascular disease. About 695,000 people in the United States died from heart disease in 2021—that is one in every five deaths. Cardiovascular disease costs consume an astronomical number of financial resources, including about \$239.9 billion annually. While the incidence of cardiovascular disease has plateaued in developed nations, it continues to rise in middle- and low-income countries.

It does not have to be this way.

Inflammation is one of the biological mechanisms that cause cardiovascular disease. There is some evidence that multiple traditional cardiac risk factors, including hypertension, diabetes mellitus, and hyperlipidemia, are all associated with inflammation.

Psychological stress is now considered an independent risk factor for cardiovascular disease. Excessive stress can both initiate and perpetuate cardiovascular disease. Emotional stress induces genetic and endocrinal changes that perpetuate inflammation in blood vessels, leading to heart attack, stroke, or peripheral arterial disease. Furthermore, stress also amplifies sympathetic discharge and attenuates parasympathetic discharge, and this imbalance may cause arrhythmias.

Chronic stress is toxic, generating a cascade of inflammatory cytokines that decrease immunity and generate vascular inflammation. Over time, everyday stresses such as being stuck in traffic, financial pressures, and relationship issues may contribute to chronic inflammation and cardiovascular disease.

Fortunately, stress comes not just from what we do; more important is how we *react* to what we do. By practicing stress management techniques such as yoga and meditation on a regular basis, even a few minutes a day, we can buffer the harmful effects of stress. As a patient once shared with me, “I used to have a short fuse and would explode easily. Now, my fuse is longer. Even if the situation hasn’t changed, *I* have.”

My colleagues and I conducted randomized controlled trials documenting, for the first time, that a lifestyle medicine intervention including a whole foods plant-based diet low in fat, sugar, and refined carbohydrates, moderate exercise, stress management (including yoga), and social support can often reverse the progression of even severe coronary heart disease, without drugs or surgery.

Over the last few decades, scientific evidence of the many beneficial effects of yoga has been found through genetic, epigenetic, molecular, and cellular studies. While yoga as a series of postures has become popular worldwide, it is important to remember that although all these postures are useful, yoga is much more than a handful of physical exercises. It is, in fact, a cumulative practice of physical exercise, specialized breathing techniques, and mindfulness meditation. It quiets down the mind and body, enabling us to experience an inner sense of peace and well-being that is always there if we just stop disturbing it.

This book presents the clinical and research evidence of yoga’s role in cardiovascular diseases as a preventive and therapeutic strategy. It combines decades of research that enables physicians to use yoga as a clinical methodology to treat and prevent many diseases. It also highlights the existing research on the power of yoga and outlines future research strategies to better understand yoga’s role. Yoga is freely available, requiring no costly equipment or technology. Patience and practice are the only requirements.

Dr. Indranill Basu-Ray is an eminent Cardiologist and a Cardiac Electrophysiologist at the forefront of yoga research today. He is one of the authors of the American Heart Association’s statement on using meditation for cardiovascular risk reduction. He has been practicing yoga, including deep meditation, since age six. Trained by various Himalayan masters, he has been a practitioner of Kriya Yoga. He was initiated into Kriya Yoga by Swami Hariharananda Giri, the brother disciple of Paramhansa Yogananda who wrote the classic book, *Autobiography of a Yogi*.

Dr. Basu-Ray’s book is a combined effort of around 40 eminent researchers and clinicians. Every chapter has been compiled with the latest updates included. Thus, this book is a storehouse of information on clinical yoga therapy for clinicians and researchers. Also, every chapter is clinically oriented for healthcare professionals to use in daily clinical

practice. It details the yogic postures used in clinical trials for many different diseases and provides guidelines on prevention and therapeutic use. It also provides recommendations for future research topics that can help move the science of yoga forward.

I commend Dr. Basu-Ray and the coauthors for compiling such a monumental book that brings to light the research on yoga to enable its clinical use. This endeavor will inspire many clinicians to practice yoga therapy as a cost-effective and medically effective modality to treat and prevent cardiovascular diseases.

**Dean Ornish, MD**

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# Preface

After spending over two decades learning, teaching, and mentoring residents and fellows in Medicine and Cardiology, I was always intrigued by the epidemic explosion of cardiovascular disorders worldwide. As medical students, we had patients admitted with heart attacks, predominantly in their 50s and 60s. Contrarily, today, we find that no age is a bar. We have had multiple patients with clinically significant coronary artery disease, even in their 30s. This spurred my interest to go beyond clinical medicine and understand the cause and remedy for such an epidemic. It is undeniable that medicine has made tremendous strides not only in unraveling the pathophysiology of diseases but also in management, with technological advancement occurring almost every day. Despite this, there has been no respite in the evolving heart disease numbers.

I have been a practitioner of Kriya yoga for over three decades now. This robust protocol includes physical exercise, modulated breathing, mindfulness, and meditation. My yoga mentor, Swami Hariharananda Giri, a monk of the Kriya Yoga clan, wanted me to become a cardiologist, understand and explain the mechanism of yoga action scientifically, and spread it to the ordinary person to ensure health and well-being. “Yoga is a potent mechanism to achieve every goal in life, certainly health,” he contended. “However, it needs to be understood and spread scientifically.” My graduation to be a cardiologist was long and arduous as I had to repeat my training in the United States after being initially trained in India. However, this extended association with learning and research in some of the topmost institutions in the world espoused me to think about the possible reason why even low- and middle-income countries (LMICs) of the world seem to be having a deluge of coronary artery disease. In the United States, nearly one in three (~80 million) adults have cardiovascular disease (CVD), which imparts a heavy economic burden, including estimated direct costs of approximately \$500 billion. It has been projected that by 2035, nearly half of the U.S. population will have some form of cardiovascular disease. Even nations with a younger population, like India, have an explosion of cardiovascular disease in a malignant form that affects much younger population with more severe disease.

My experience and understanding of yoga’s essence helped me find an answer. The basic tenets of yoga say that the mind and body are like one entity—they keep each other informed at every second of our existence. Thus, an aberrant mental state garnered by diurnal experience in a world of stress and competitiveness evokes a “flight and fight” reaction, activating genes, hormones, and pathophysiological changes that induce heart diseases. Aberrant lifestyle added to the increased stress of existence as is ostensible today have clubbed together to create a dangerous cascade of heart attacks, heart failure, arrhythmia, and death. Almost half the planet’s population suffers from hypertension, a harbinger of other dangerous cardiac diseases. Thus, the cure is only possible if we quieten the mind and douse the inflammatory fire within the body by extinguishing the initial flame initiated inside our brains.

The scientific interrogation of yoga started relatively late in the West but was a welcome change. Funding of such research by the National Institute of Health and the rising popularity of yoga are some of the reasons for this. Many researchers started studying yoga’s clinical effects in the last few decades. Numerous leading oncology institutions started implementing yoga protocols as part of their treatment strategies. It is fair to state that oncology led the way to implement yogic therapy in medicine.

Cardiovascular disease remains the largest killer on this planet, killing twice the number of people than cancer. There is robust 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 of CVD, responsible for the overwhelming majority of mortality on earth. Accumulated evidence in the last decade points to the stress-mediated genetic, epigenetic, and endocrinal changes perpetuating inflammation in blood vessels, leading to heart attack, stroke, or peripheral arterial disease. Yoga has been shown to attenuate many such pathological entities through stress reduction. Aging is a risk factor for aberrant pathophysiological changes leading to increased risk of coronary artery disease and arrhythmias. There is some initial evidence that yoga may help reduce cellular aging. Moreover, it is now established that organ aging, particularly that of the brain, can be decreased by sustained yoga practice. Meditation has been shown to help

the growth of different regions of the cerebral cortex, which now remains firmly substantiated through multiple imaging studies among different cohorts of volunteers. CVD imparts a heavy economic burden on our healthcare system. The CVD costs of care continue to rise, with the current expenses for treatment accounting for nearly \$1 of every \$6 spent on healthcare. Yoga can help lower this cost through its proven effectiveness in primordial, primary, and secondary prevention.

*Yoga for Cardiovascular Disease and Rehabilitation: Integrating Complementary Medicine into Cardiovascular Medicine* elaborates recent research, clinical trials, and experiments on yoga and meditation as a preventative measure and treatment for various major cardiovascular diseases, including hypertension, hyperlipidemia, coronary artery disease, and metabolic syndromes. It also discusses the current knowledge of yoga's role in ameliorating cardiac dysfunction initiated by emotion and other factors that create and perpetuate vascular inflammation. Cellular, genetic, and molecular effects of yoga based on experimental evidence are also covered in detail, providing readers with the latest research on the impact of yoga and meditation on heart disease. This book also explores current knowledge gaps in yoga research to facilitate further research. It is a comprehensive reference to physicians, scientists, and clinicians interested in understanding yoga's role in preventing and treating cardiovascular diseases. This book adopts a translational approach, exploring yoga's clinical, cellular, genetic, and molecular effects on health based on the latest research evidence.

This book would never have seen the light of day without the belief and support of my acquisition editor, Stacy Masucci, who believed in me and the power of yoga as a potent healing entity. I also remain thankful to the Elsevier team, including Ana Garcia and Tracy Lange, for contributing to this project. I remain immensely grateful to Ms. Kristi Anderson and Ms. Billie Jean Fernandez, my editorial project managers, whose astute working ethics and friendly ambiance helped me throughout the long and arduous process of writing the book. I am grateful to all the authors who collaborated with me to create this unique work. Most of them are busy clinicians and researchers with extensive experience in both clinical medicine and yoga. I am also thankful to my postdoctorate research scholars, led by Dr. Sukhendu Mandal, Dr. Inbaraj G and Dr. Manjot Singh, and my doctoral research volunteer, Ms. Khusboo Arya, and my graduate research scholars, led by Reetoban Dutta, including Oishi Roy Choudhury, Nandita Bhalla, Nimalidinne Krishna Vani, Abinay Siva Kumar Reddy, and Mridul Sarangal, without whose dedication and hard work it would have been impossible for me to complete this substantial undertaking.

I am finally thankful to my wife Julie and my son Ishan, who had to put up with my being busy with this project evening after evening for over a year that I could have spent with them. Without their substantial help and sacrifice, this project would have never seen completion.

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*Memphis, TN, United States*

# Abbreviations

<b>18F-FDG</b>	18F-fluorodeoxyglucose
<b>5HT</b>	5-hydroxytryptamine
<b>AA</b>	African American
<b>AACE</b>	American Association of Clinical Endocrinologists
<b>AACPR</b>	American Association of Cardiovascular and Pulmonary Rehabilitation
<b>AADs</b>	Antiarrhythmic Drugs
<b>ABPM</b>	Ambulatory Blood Pressure Monitoring
<b>ACC</b>	American College of Cardiology
<b>ACC/AHA</b>	American College of Cardiology/American Heart Association
<b>ACCF</b>	American College of Cardiology Foundation
<b>ACE</b>	Angiotensin-Converting Enzyme
<b>ACEI</b>	Angiotensin Converting Enzyme Inhibitor
<b>ACPA</b>	Anti-Citrullinated Protein Antibody
<b>ACS</b>	Acute Coronary Syndrome
<b>ACTH</b>	Adrenocorticotrophic Hormone
<b>AD</b>	Alzheimer's Disease
<b>ADA</b>	American Diabetes Association
<b>ADAS</b>	Alzheimer's Disease Assessment Scale
<b>ADM</b>	Adrenomedullin
<b>ADMA</b>	Asymmetric Dimethylarginine
<b>AEs</b>	Adverse Events
<b>AEBs</b>	Abnormal Eating Behaviors
<b>AF</b>	Atrial Fibrillation
<b>AFR</b>	Africa Region
<b>AG</b>	Acylated Ghrelin
<b>AGB</b>	Adjustable Gastric Band
<b>AGi</b>	Alpha-Glucosidase Inhibitor
<b>AHA</b>	American Heart Association
<b>AHD</b>	Atherosclerotic Heart Disease
<b>AI</b>	Aortic Insufficiency
<b>AIR</b>	Acute phase Insulin Release
<b>AMI</b>	Acute Myocardial Infarction
<b>AMPK</b>	AMP-activated Protein Kinase
<b>ANB</b>	Alternate Nostril Breathing
<b>ANG</b>	Angiogenin
<b>ANS</b>	Autonomic Nervous System
<b>ANT</b>	Attentional Network Task
<b>ApoAII</b>	Apolipoprotein A II
<b>AR</b>	Aortic Regurgitation
<b>ARBs</b>	Angiotensin II Receptor Blockers
<b>ARC</b>	Hypothalamic Arcuate Nucleus
<b>ARIC</b>	Atherosclerosis Risk in Communities
<b>ARNI</b>	Angiotensin Receptor blockade with Nephilysin Inhibition
<b>AS</b>	Ankylosing Spondylitis
<b>AS</b>	Aortic Stenosis
<b>ASCVD</b>	Atherosclerotic Cardiovascular Disease

<b>ASL</b>	Arterial Spin Labeling
<b>ASPC</b>	American Society for Preventive Cardiology
<b>ATP III</b>	Adult Treatment Panel III
<b>AUDIT</b>	Alcohol Use Disorder Identification Test
<b>AV</b>	Atrioventricular
<b>AVN</b>	Atrio-ventricular Node
<b>AVR</b>	Aortic Valve Replacement
<b>AY</b>	Ananda Marga Yoga
<b>AYUSH</b>	Ayurveda, Yoga, Unani, Siddha, Homeopathy
<b>BA</b>	Breathing Awareness
<b>BBS</b>	Berg Balance Scale
<b>BDI-II</b>	Beck Depression Inventory-II scale
<b>BDNF</b>	Brain-Derived Neurotrophic Factor
<b>BDNP</b>	Brain-derived Natriuretic Peptide
<b>BE</b>	Energy Balance
<b>BER</b>	Base Excision Repair
<b>BF%</b>	Body Fat Percentage
<b>BFM</b>	Body Fat Mass
<b>BIA</b>	Bioelectrical Impedance
<b>BMI</b>	Body Mass Index
<b>BNP</b>	Brain Natriuretic Peptide
<b>BP</b>	Blood Pressure
<b>BPD</b>	Biliopancreatic Diversion
<b>BPD/DS</b>	Biliopancreatic Diversion with Duodenal Switch
<b>BPM</b>	Beats Per Minute
<b>BSX</b>	Brain-Specific Homeobox Domain
<b>BW</b>	Body Weight
<b>CABG</b>	Coronary Artery Bypass Grafting
<b>CAD</b>	Coronary Artery Disease
<b>CAG</b>	Coronary Angiography
<b>CAM</b>	Complementary and Alternate Medicine
<b>CaMKK2</b>	Calcium/Calmodulin-dependent Protein Kinase Kinase 2
<b>CBF</b>	Cerebral Blood Flow
<b>CDC</b>	US Centers for Disease Control and Prevention
<b>CDS</b>	Cardiac Depression Scale
<b>CFR</b>	Coronary Flow Reserve
<b>CG</b>	Control Group
<b>CGI-S</b>	Clinical Global Impression Severity
<b>CHD</b>	Coronary Heart Disease
<b>CHF</b>	Congestive Heart Failure
<b>CI</b>	Confidence Interval
<b>CIA</b>	Chronic Inflammatory Arthritis
<b>cIMT</b>	Carotid Intimal Thickness
<b>CKD</b>	Chronic Kidney Disease
<b>CM</b>	Control Meditation
<b>CMP</b>	Cardiomyopathy
<b>CNP</b>	Chandra Nadi Pranayama
<b>CNS</b>	Central Nervous System
<b>CO</b>	Canola Oil
<b>CO</b>	Cardiac Output
<b>COPD</b>	Chronic Obstructive Pulmonary Disease
<b>COWS</b>	Clinical Opiate Withdrawal Scale
<b>COX-2</b>	Cyclooxygenase 2
<b>CPGs</b>	Clinical Practice Guidelines
<b>CPT</b>	Carnitine Palmitoyltransferase
<b>CR</b>	Cardiac Rehabilitation
<b>CRA</b>	Comparative Risk Assessment
<b>CREB</b>	cAMP Response Element-Binding Protein

<b>CRF</b>	Cardiorespiratory Fitness
<b>CRF</b>	Corticotrophin-Releasing Factor
<b>CRH</b>	Corticotrophin-Releasing Hormone
<b>CRP</b>	C-Reactive Protein
<b>CRT</b>	Cardiac Resynchronization Therapy
<b>CRT-D</b>	Cardiac Resynchronization Therapy with Defibrillator
<b>CS</b>	Coronary Sinus
<b>CSA</b>	Chronic Stable Angina
<b>CSD</b>	Cardiac Sympathetic Denervation
<b>CSF</b>	Cerebral Spinal Fluid
<b>CSMMU</b>	Chhatrapati Shahuji Maharaj Medical University (Formerly King George's Medical University)
<b>CSP</b>	Cortical Silent Period
<b>CT</b>	Computed Tomography
<b>CT CAG</b>	Computed Tomography Coronary Angiography
<b>CT-FFR</b>	Computed Tomography–derived Fractional Flow Reserve
<b>CTLA4</b>	Cytotoxic T-Lymphocyte-Associated protein 4
<b>CTRA</b>	Conserved Transcriptional Response to Adversity
<b>CUD</b>	Cannabis Use Disorder
<b>CUD</b>	Cocaine Use Disorder
<b>CV</b>	Cardiovascular
<b>CVA</b>	Cerebrovascular Accident
<b>CVC</b>	Comprehensive Valve Center
<b>CVD</b>	Cardiovascular Disease
<b>CVEs</b>	Cardiac Vascular Events
<b>CVH</b>	Cardiovascular Health
<b>CVPR</b>	Cardiovascular and Pulmonary Rehabilitation
<b>CVRFs</b>	Cardiovascular Risk Factors
<b>CYP</b>	Common Yoga Protocol
<b>D-MARDs</b>	Disease-Modifying Anti-Rheumatic Drugs
<b>D-TGAs</b>	D-Transposition of Great Arteries
<b>DAG</b>	Directed Acyclic Graph
<b>DALY</b>	Disability Adjusted Life-Years
<b>DAMP</b>	Damage-Associated Molecular Patterns
<b>DAN</b>	Dorsal Attention Network
<b>DASH</b>	Dietary Approaches to Stop Hypertension
<b>DASI</b>	Duke Activity Status Scale
<b>DASS-21</b>	Depression Anxiety Stress Scale
<b>DAYS</b>	Diabetes and Yoga Study
<b>DBP</b>	Diastolic Blood Pressure
<b>DC</b>	Direct Cardioversion
<b>DHA</b>	Docosahexaenoic Acid
<b>DHEAS</b>	Dehydroepiandrosterone Sulfate
<b>DLCO</b>	Diffusion Capacity of the Lungs for Carbon Monoxide
<b>DLPFC</b>	Dorsolateral Prefrontal Cortex
<b>DM</b>	Diabetes Mellitus
<b>DM</b>	Type II Diabetes Mellitus
<b>DMN</b>	Default Mode Network
<b>DNA</b>	Deoxyribonucleic Acid
<b>Do-P</b>	Double Product
<b>DPP</b>	Diabetes Prevention Program
<b>DPP-4i</b>	Dipeptidyl Peptidase-4 Inhibitor
<b>DPPOS</b>	U.S. Diabetes Prevention Program Outcomes Study
<b>DPS</b>	Diabetes Prevention Study
<b>DREAM</b>	Diabetes REDuction Approaches with ramipril and rosiglitazone Medications
<b>DSM-5</b>	Diagnostic and Statistical Manual-5
<b>DSM-IV</b>	Diagnostic and Statistical Manual-IV
<b>DTV</b>	Device-Treated Ventricular Events

<b>DUDIT</b>	Drug Use Disorders Identification Test
<b>DVD</b>	Double Vessel Disease
<b>DYS</b>	Diabetes Yoga Protocol
<b>EASD</b>	European Association for the Study of Diabetes
<b>EC SOD</b>	Extracellular Superoxide Dismutase
<b>ECG</b>	Electrocardiography
<b>ECN</b>	Executive Control Network
<b>EDs</b>	Eating Disorders
<b>EDD</b>	End Diastolic Dimension
<b>EEG</b>	Electroencephalography
<b>EGIR</b>	European Group for the study of Insulin Resistance
<b>EKG</b>	Electrocardiography
<b>ELR</b>	External Loop Recorder
<b>EMG</b>	Electromyography
<b>EMS</b>	Emergency Medical Services
<b>ENDS</b>	Electronic Nicotine Delivery Systems
<b>ENNDS</b>	Electronic Non-Nicotine Delivery Systems
<b>EPs</b>	Evoked Potentials
<b>EPA</b>	Eicosapentaenoic Acid
<b>EPIC</b>	European Prospective Investigation into Cancer and Nutrition
<b>EPS</b>	Electrophysiological Studies
<b>EQ-QOL</b>	European Quality of Life
<b>ERO</b>	Effective Regurgitant Orifice
<b>ERPs</b>	Event-Related Potentials
<b>ES</b>	Eisenmenger Syndrome
<b>ESC</b>	European Society of Cardiology
<b>ESC/EAS</b>	European Society of Cardiology/European Atherosclerosis Society
<b>ESC/ESH</b>	European Society of Cardiology and European Society of Hypertension
<b>ESD</b>	End Systolic Dimension
<b>ESR</b>	Erythrocyte Sedimentation Rate
<b>EULAR</b>	European League Against Rheumatism
<b>FA</b>	Fatty Acid
<b>FB</b>	Fast Breathing
<b>FBG</b>	Fasting Blood Glucose
<b>FBS</b>	Fasting Blood Sugar
<b>FDA</b>	Food and Drug Administration
<b>FDS</b>	Forward Digit Span
<b>FEC</b>	Functional Exercise Capacity
<b>FFA</b>	Free Fatty Acid
<b>FH</b>	Familial Hyperlipidemia
<b>FMC</b>	First Medical Contact
<b>fMRI</b>	Functional Magnetic Resonance Imaging
<b>FOXO1</b>	Forkhead Box 1
<b>FRS</b>	Framingham Risk Score
<b>FS</b>	Flourishing Scale
<b>FVC</b>	Forced Vital Capacity
<b>GABA</b>	Gamma-amino Butyric Acid
<b>GAD</b>	Generalized Anxiety Disorder
<b>GBD</b>	Global Burden of Disease
<b>GCs</b>	Glucocorticoids
<b>GDM</b>	Gestational Diabetes Mellitus
<b>GDMT</b>	Guideline-Directed Medical Therapy
<b>GDS15</b>	Geriatric Depression Scale-15
<b>GH</b>	Growth Hormone
<b>GHDx</b>	Global Health Data Exchange
<b>GI</b>	Glycemic Index
<b>GL</b>	Glycemic Load
<b>GLN</b>	Glinide

<b>GLP-1 RA</b>	Glucagon-like Peptide-1 Receptor Agonist
<b>GM</b>	Gray Matter
<b>GMV</b>	Gray Matter Volume
<b>GP</b>	Ganglionated Plexus
<b>GPCR</b>	G-protein-Coupled Receptor
<b>GR</b>	Glutathione Reductase
<b>GSH</b>	Glutathione
<b>GST</b>	Glutathione S-transferase
<b>GXT</b>	Graded Exercise Test
<b>HAM-A</b>	Hamilton Anxiety Rating Scale
<b>HAM-D</b>	Hamilton's Depression Rating Scale
<b>HAQ-DI</b>	Health Assessment Questionnaire Disability Index
<b>HbA1c</b>	Glycosylated Hemoglobin
<b>Hbdiff</b>	Hemoglobin difference
<b>HC</b>	Hip Circumference
<b>HDAC</b>	Histone Deacetylase
<b>HDL</b>	High-Density Lipoprotein
<b>HF</b>	Heart Failure
<b>HFimpEF</b>	Heart Failure with Improved Ejection Fraction
<b>HFmrEF</b>	Heart Failure with Mildly Reduced Ejection Fraction
<b>HFpEF</b>	Heart Failure with Preserved Ejection Fraction
<b>HFrEF</b>	Heart Failure with Reduced Ejection Fraction
<b>HGP</b>	Hepatic Glucose Production
<b>HIV</b>	Human Immunodeficiency Virus
<b>HLA-B27</b>	Human Leukocyte AntigenB27
<b>HMGCoA</b>	Hydroxymethylglutaryl-coenzyme A
<b>HMPAO</b>	Hexamethylpropyleneamine Oxime
<b>HOMA-IR</b>	Homeostatic Model Assessment for Insulin Resistance
<b>HPA</b>	Hypothalamic Pituitary Adrenal Axis
<b>HR</b>	Hazard Ratio
<b>HR</b>	Heart Rate
<b>HR-QoL</b>	Health-Related Quality of Life
<b>HRV</b>	Heart Rate Variability
<b>hs-CRP</b>	Highly Sensitive C Reactive Protein
<b>HsTnI</b>	Highly Sensitive Troponin I
<b>HTN</b>	Hypertension
<b>HTP</b>	Heated Tobacco Product
<b>HY</b>	Hathayoga
<b>I/G Ratio</b>	Insulin/Glucagon Ratio
<b>IAS</b>	Interatrial Septum
<b>ICD</b>	International Classification of Diseases
<b>ICD</b>	Implantable Cardioverter Defibrillator
<b>ICD-10</b>	International Classification of Diseases, 10th Revision
<b>ICMR-INDIAB</b>	Indian Council of Medical Research-India Diabetes
<b>ICPPR</b>	International Council of Cardiovascular Prevention and Rehabilitation
<b>IDF</b>	International Diabetes Federation
<b>IDL</b>	Intermediate Density Lipoprotein
<b>IFG</b>	Impaired Fasting Glucose
<b>IFN</b>	Interferon
<b>IGT</b>	Impaired Glucose Intolerance
<b>IHD</b>	Ischemic Heart Disease
<b>IKK</b>	Inhibitor of Nuclear Factor- $\kappa$ B Kinase
<b>IL</b>	Interleukin
<b>IL-6</b>	Interleukin-6
<b>ILR</b>	Implantable Loop Recorder
<b>IMT</b>	Intima-Media Thickness
<b>INR</b>	Indian Rupee

<b>IR</b>	Insulin Resistance
<b>IRF</b>	Interferon Regulatory Factor
<b>IRFs</b>	Interferon Response Factors
<b>ISH</b>	International Society of Hypertension
<b>IV</b>	Inverse Variance
<b>IV</b>	Intravenous
<b>IVC</b>	Inferior Vena Cava
<b>IVS</b>	Interventricular Septum
<b>JD</b>	Japan Diet
<b>K10</b>	Kessler Psychological Distress Scale
<b>KKM</b>	Kirtan Kriya Meditation
<b>KOR</b>	Kappa Opioid Receptor
<b>LA</b>	Linolenic Acid
<b>LCDs</b>	Low-Calorie Diets
<b>LCT</b>	Letter Cancellation Test
<b>LDL</b>	Low Density Lipoprotein
<b>LDL-C</b>	Low Density Lipoprotein Cholesterol
<b>LF/HF Ratio</b>	Low Frequency/High Frequency Ratio
<b>LHPA</b>	Limbic Hypothalamic Pituitary Adrenal Axis
<b>LNB</b>	Left Nostril Breathing
<b>Low-MEE</b>	Low Myocardial Mechano-Energetic Efficiency
<b>LPFC</b>	Left Prefrontal Cortex
<b>LPS</b>	Lipopolysaccharide
<b>LV and RV</b>	Left Ventricle and Right Ventricle
<b>LV</b>	Left Ventricle
<b>LVAD</b>	Left Ventricular Assist Device
<b>LVEDP</b>	Left Ventricular End Diastolic Pressure
<b>LVEDV</b>	Left Ventricular End Diastolic Volume
<b>LVEF</b>	Left Ventricular Ejection Fraction
<b>LVH</b>	Left Ventricular Hypertrophy
<b>MACEs</b>	Major Adverse Cardiac Events
<b>MAP</b>	Mean Arterial Blood Pressure
<b>MASALA</b>	Mediators of Atherosclerosis in South Asians Living in America
<b>MB</b>	Moderator Band
<b>MBIs</b>	Mind Body Interventions
<b>MBSR</b>	Mindfulness-Based Stress Reduction
<b>MBTs</b>	Mind Body Therapies
<b>MC3R</b>	Melanocortin Receptor 3
<b>MCP-1</b>	Monocyte Chemotactic Protein-1
<b>MCS</b>	Mechanical Circulatory Support
<b>MDA</b>	Malondialdehyde
<b>MDD</b>	Major Depressive Disorder
<b>MDMA</b>	3, 4-Methylenedioxymethamphetamine
<b>MEG</b>	Magnetoencephalography
<b>MET</b>	Metabolic Equivalents
<b>MET</b>	Metformin
<b>Meth</b>	Methamphetamine
<b>MetS</b>	Metabolic Syndrome
<b>MI</b>	Myoinositol
<b>MI</b>	Myocardial Infarction
<b>MINOCA</b>	Myocardial Infarction with Nonobstructive Coronary Arteries
<b>MLwHFQ</b>	Minnesota Living with Heart Failure Questionnaire
<b>MM</b>	Mindfulness Meditation
<b>MnSOD</b>	Manganese Superoxide Dismutase
<b>MnSOR</b>	Methionine Sulfoxide Reductase
<b>MNT</b>	Medical Nutrition Therapy
<b>MONICA</b>	Monitoring of Trends and Determinants in Cardiovascular Disease
<b>MRC</b>	Medical Research Council of Great Britain

<b>MRI</b>	Magnetic Resonance Imaging
<b>MRS</b>	Magnetic Resonance Spectroscopy
<b>MS</b>	Mitral Stenosis
<b>MSU</b>	Monosodium Urate
<b>MT</b>	Medical therapy
<b>mtDNA</b>	Mitochondrial DNA
<b>mTOR</b>	Mammalian Target of Rapamycin
<b>MUFA</b>	Mono Unsaturated Fatty Acid
<b>MV</b>	Mitral Valve
<b>MVA</b>	Mitral Valve Area
<b>MVR</b>	Mitral Valve Replacement
<b>NA</b>	Not Available
<b>NAA</b>	N-acetyl aspartate
<b>NAD</b>	Nicotinamide Adenine Dinucleotide
<b>NAVIGATOR</b>	Nateglinide and Valsartan in Impaired Glucose Tolerance Outcomes Research
<b>NCCIH</b>	National Center for Complementary and Integrated Health
<b>NCD</b>	Non-Communicable Disease
<b>NCEP</b>	National Cholesterol Education Program
<b>NCEP:ATP III</b>	National Cholesterol Education Program Adult Treatment Panel III
<b>NCHS</b>	National Center for Health Statistics
<b>NCS</b>	Nerve Conduction Studies
<b>NE</b>	Norepinephrine
<b>NET</b>	Neutrophil Extracellular Trap
<b>NF-<math>\kappa</math>B</b>	Nuclear Factor Kappa B
<b>NFHS-3</b>	National Family Health Survey-3
<b>NHANES</b>	National Health and Nutrition Examination Survey
<b>NHIS</b>	National Health Interview Survey
<b>NHLBI</b>	National Heart, Lung, and Blood Institute
<b>NICE</b>	National Institute for Health and Care Excellence
<b>NIDDM</b>	Non-Insulin-Dependent Diabetes Mellitus
<b>NMA</b>	Network Meta-Analysis
<b>NO</b>	Nitric Oxide
<b>NOS</b>	Nitric Oxide Synthetase
<b>NPY/AgRP</b>	Neuropeptide Y/Agouti-Related Peptide
<b>NS</b>	Nervous System
<b>NSAIDs</b>	Non-Steroidal Anti-Inflammatory Drugs
<b>NSTEMI</b>	Non-ST-segment Elevation Myocardial Infarction
<b>NTProBNP</b>	N-terminal Pro B-type Natriuretic Peptide
<b>NYHA</b>	New York Heart Association
<b>ODS</b>	Opioid Dependence
<b>OGTT</b>	Oral Glucose Tolerance Test
<b>OHQ</b>	Oxford Happiness Questionnaire
<b>OO</b>	Olive Oil
<b>OS</b>	Oxidative Stress
<b>OSA</b>	Obstructive Sleep Apnea
<b>ODUs</b>	Opioid Use Disorders
<b>OXPHOS</b>	Oxidative Phosphorylation
<b>p-mTOR</b>	Phosphorylated Mammalian Target of Rapamycin
<b>PA</b>	Physical Activity
<b>PA</b>	Pulmonary Artery
<b>PAD</b>	Peripheral Artery Disease
<b>PAF</b>	Paroxysmal Atrial Fibrillation
<b>PAMPK</b>	Phosphorylated AMP-Activated Protein Kinase
<b>PANAS</b>	Positive and Negative Affect Scale
<b>PASP</b>	Pulmonary Artery Systolic Pressure
<b>PAX</b>	Parasternal Long Axis view
<b>PBMC</b>	Peripheral Blood Mononuclear Cell
<b>PCI</b>	Percutaneous Intervention

<b>PCOS</b>	Polycystic Ovarian Syndrome
<b>PD</b>	Panic Disorder
<b>PD</b>	Parkinson's Disease
<b>PE</b>	Pulmonary Embolism
<b>PET</b>	Positron Emission Tomography
<b>PFC</b>	Prefrontal Cortex
<b>PFT</b>	Pulmonary Function Test
<b>PGC1<math>\alpha</math></b>	Peroxisome Proliferator-Activated Receptor- $\gamma$ Coactivator
<b>PHP</b>	Personalized Health Planning
<b>PHT</b>	Pressure Half Time
<b>PISA</b>	Proximal Hypovelocitv Hemispheric Surface Area
<b>PM</b>	Progressive Relaxation Meditation
<b>PMBC</b>	Percutaneous Mitral Balloon Commissurotomy
<b>PNMT</b>	Phenylethanolamine N-methyltransferase
<b>PNS</b>	Parasympathetic Nervous System
<b>POTS</b>	Postural Tachycardia Syndrome
<b>PPAR<math>\gamma</math></b>	Peroxisome Proliferator-Activated Receptor-Gamma
<b>PPBG</b>	Postprandial Blood Glucose
<b>PPBS</b>	Postprandial Blood Sugar
<b>PPI</b>	Permanent Pacemaker Implantation
<b>PROBE</b>	Prospective Randomized Open Blinded End-Point
<b>PROMs</b>	Patient-Related Outcome Measures
<b>PsA</b>	Psoriatic Arthritis
<b>PsO</b>	Psoriasis
<b>PTCA</b>	Percutaneous Transluminal Coronary Angioplasty
<b>PTSD</b>	Post-Traumatic Stress Disorder
<b>PUFA</b>	Poly Unsaturated Fatty Acid
<b>PURE</b>	Prospective Urban and Rural Epidemiological Study
<b>PVs</b>	Pulmonary Veins
<b>PVCs</b>	Premature Ventricular Contractions
<b>QoL</b>	Quality of Life
<b>QR</b>	Quick Release
<b>QTd</b>	QT Dispersion
<b>RA</b>	Rheumatoid Arthritis
<b>RAAS</b>	Renin–Angiotensin–Aldosterone System
<b>RAS</b>	Renin–Angiotensin System
<b>RBO</b>	Rice Bran Oil
<b>rCBF</b>	Regional Cerebral Blood Flow
<b>rCMRGlc</b>	Regional Cerebral Metabolic Rate of Glucose Consumption
<b>RCT</b>	Randomized Controlled Trial
<b>RDS</b>	Reverse Digit Span Test
<b>RES</b>	Restorative Hatha Yoga
<b>RF</b>	Rheumatoid Factor
<b>RF</b>	Regurgitant Fraction
<b>RFA</b>	Radio Frequency Ablation
<b>RFFT</b>	Ruff Figural Fluency Test
<b>RM</b>	Rajyoga Meditation
<b>RM</b>	Relaxing Music
<b>RMSSD</b>	Root Mean Square of Successive Differences between normal heartbeats
<b>RNB</b>	Right Nostril Breathing
<b>RNS</b>	Reactive Nitrogen Species
<b>ROI</b>	Region of Interest
<b>ROM</b>	Range of Motion
<b>ROS</b>	Reactive Oxygen Species
<b>RPFC</b>	Right Prefrontal Cortex
<b>RPP</b>	Rate Pressure Product
<b>RSNs</b>	Resting-State Networks
<b>RSPV</b>	Right Superior Pulmonary Vein
<b>RVol</b>	Regurgitant Volume
<b>RYGB</b>	Roux-en-Y Gastric Bypass
<b>S/P</b>	Status Post

<b>SAEs</b>	Serious Adverse Events
<b>SAN</b>	Sino-atrial Node
<b>SAT</b>	Scholastic Assessment Test
<b>SAX</b>	Parasternal Short Axis view
<b>SB</b>	Slow Breathing
<b>SBP</b>	Systolic Blood Pressure
<b>SBWI</b>	Standard Behavioral Weight-loss Intervention
<b>SCD</b>	Sudden Cardiac Death
<b>SD</b>	Standard Deviation
<b>SDNNi</b>	Standard Deviation of NN intervals Index
<b>SEAR</b>	South East Asian Region
<b>SES</b>	Social Economic Status
<b>SF12</b>	Short-Form Health Survey
<b>SFA</b>	Saturated Fatty Acid
<b>SGLT2i</b>	Sodium-Glucose Transporter 2 Inhibitor
<b>sHLA-G</b>	Soluble Human Leukocyte Antigen
<b>SICI</b>	Short Intra-Cortical Inhibition
<b>SIHD</b>	Stable Ischemic Heart Disease
<b>SIRT1</b>	Sirtuin1
<b>SKY</b>	Sudarshan Kriya Yoga
<b>SMART</b>	Specific, Measurable, Achievable, Realistic, Time-limited
<b>SMC</b>	Smooth Muscle Cell
<b>SNS</b>	Sympathetic Nervous System
<b>SNS-HPA</b>	Sympathetic Nervous System–Hypothalamic Pituitary Adrenal Axis
<b>SOD</b>	Superoxide Dismutase
<b>SpAs</b>	Spondyloarthritides
<b>SPANES</b>	Scale of Positive and Negative Experience
<b>SPECT</b>	Single Photon Emission Computed Tomography
<b>SR</b>	Systematic Review
<b>SSRI</b>	Selective Serotonin Reuptake Inhibitors
<b>STAI</b>	State-Trait Anxiety Inventory
<b>STEMI</b>	ST Elevation Myocardial Infarction
<b>STS</b>	Society of Thoracic Surgeons
<b>SU</b>	Sulfonylurea
<b>SUD</b>	Stimulant Use Disorder
<b>SVC</b>	Slow Vital Capacity
<b>SVC</b>	Superior Vena Cava
<b>SVT</b>	Supraventricular Tachycardia
<b>SY</b>	Sahaja Yoga
<b>T2DM</b>	Type 2 Diabetes Mellitus
<b>ta-VNS</b>	Transcutaneous Auricular Vagal Nerve Stimulation
<b>TAC</b>	Total Antioxidant Capacity
<b>TAK1</b>	Transforming growth factor- $\beta$ -activated kinase 1
<b>TAS</b>	Total Anti-Oxidant Stress
<b>TAVI</b>	Transcatheter Aortic Valve Implantation
<b>TBs</b>	Tibetan Buddhists
<b>TB</b>	Tuberculosis
<b>TC</b>	Total Cholesterol
<b>TCIM</b>	Traditional, Complementary, and Integrative Medicine
<b>tDCS</b>	Transcranial Direct Current Stimulation
<b>TdP</b>	Torsades de Pointes
<b>TEE</b>	Total Energy Expenditure
<b>TEI</b>	Total Energy Intake
<b>TF</b>	Transfemoral
<b>TGs</b>	Triglycerides
<b>TGF-<math>\beta</math></b>	Transforming Growth Factor $\beta$
<b>TLCs</b>	Therapeutic Lifestyle Changes
<b>TLR9</b>	Toll-Like Receptor 9
<b>TM</b>	Transcendental Meditation
<b>TMA</b>	Trimethylamine

<b>TMAO</b>	Trimethylamine Oxidase
<b>TMS</b>	Transcranial Magnetic Stimulation
<b>TNF</b>	Tumor Necrosis Factor
<b>TNF-a</b>	Tumor Necrosis Factor-a
<b>TOF</b>	Tetralogy of Fallot
<b>TOS</b>	The Obesity Society
<b>TPM</b>	Temporary Pacing
<b>TPR</b>	Total Peripheral Resistance
<b>TRAF6</b>	TNF Receptor-Associated Factor 6
<b>TrkB</b>	Tropomyosin Receptor Kinase B
<b>TSH</b>	Thyroid Stimulating Hormone
<b>TTA</b>	Trail making Test 'A'
<b>TTB</b>	Trail making Test 'B'
<b>TVD</b>	Triple Vessel Disease
<b>TZD</b>	Thiazolidinedione
<b>UA</b>	Unstable Angina
<b>UCP2</b>	Uncoupling Protein 2
<b>UK</b>	United Kingdom
<b>UNB</b>	Unilateral Nostril Breathing
<b>UNDOC</b>	United Nation Office on Drugs and Crime
<b>UPRmt</b>	Mitochondrial Unfolded Protein Response
<b>USA</b>	United States of America
<b>VaD</b>	Vascular Disease
<b>VAS</b>	Visual Analogue Scale
<b>VBCT</b>	Voxel-Based Cortical Thickness
<b>VC</b>	Vena Contracta
<b>VEGF</b>	Vascular Endothelial Growth Factor
<b>VF</b>	Ventricular Fibrillation
<b>VHD</b>	Valvular Heart Disease
<b>VIN</b>	Vinyasa Yoga
<b>VKA</b>	Vitamin K Antagonist
<b>VLCDs</b>	Very-Low Calorie Diets
<b>VLDL</b>	Very Low Density Lipoprotein
<b>VMH</b>	Hypothalamic Ventromedial Nucleus
<b>VNS</b>	Vagal Nerve Stimulation
<b>VT</b>	Ventricular Tachycardia
<b>VVS</b>	Vasovagal Syncope
<b>WAIS—RNI</b>	Wechsler Adult Intelligence Scale—Revised Neuropsychological Instrument
<b>WC</b>	Waist Circumference
<b>WHO</b>	World Health Organization
<b>WHOQOL-BREF</b>	World Health Organization Quality of Life Scale—short version
<b>WHR</b>	Waist to Hip Ratio
<b>WHYES</b>	Women's Health, Yoga and Education Study
<b>YB</b>	Yoga Breathing
<b>YG</b>	Yoga Group
<b>YLD</b>	Years Lived with Disability
<b>YLL</b>	Years of Lives Lost
<b>YLP</b>	Yoga-Based Lifestyle Protocol
<b>Yoga-CaRe</b>	Yoga-based Cardiac Rehabilitation
<b>YOMI</b>	Yin yoga + psychoeducation and mindfulness practice
<b>YPA Scale</b>	Yoga Performance Assessment Scale
<b>YT</b>	Yoga Treatment
<b>γ-BB</b>	γ-Butyrobetaine

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# YOGA FOR CARDIOVASCULAR DISEASE AND REHABILITATION

Integrating Complementary Medicine into Cardiovascular Medicine

**Indranill Basu-Ray**

*Yoga in Cardiovascular Disease and Rehabilitation* highlights the recent research, clinical trials, and experiments on yoga and meditation as a preventative and therapeutic measure against various major cardiovascular diseases, including hypertension, hyperlipidemia, coronary artery disease, stroke, vascular dementia, and metabolic syndromes, including Diabetes Mellitus.

Cardiovascular Disease remains the largest killer on the planet. It continues to show an alarming increasing trend in most economies. Chapters discuss yoga's role in ameliorating cardiac dysfunction and the current knowledge about the effects of yoga on the brain, emotion, and vascular factors that initiate and perpetuate vascular inflammation, leading to cardiovascular mortality and morbidity. Cellular, genetic, and molecular effects of yoga based on experimental evidence are also covered in detail, providing readers with the latest research on the effects of yoga and meditation on heart diseases. The mechanism of yoga's action on the autonomic nervous system has been elucidated, explaining its role in many cardiovascular conditions, including heart failure and arrhythmias.

This book also explores current knowledge gaps in yoga research to facilitate further research and is a comprehensive reference to scientists and clinicians who are interested in yoga's health effects, including preventing and treating diseases.

It is a must-read for clinicians from those in family practice to cardiologists as most likely their patients and/or their kin either know or practice yoga, given the over 300 million yoga practitioners worldwide. It is certainly an affordable alternative in many situations, given the accelerating cost of modern medicine.

## Key Features

- Highlights all the important historical and current research, clinical trials, and experiments on yoga and meditation- as a preventative and therapeutic entity against various cardiovascular problems
- Covers all major heart diseases, including hypertension, hyperlipidemia, coronary artery disease, heart failure, stroke, diabetes mellitus, arrhythmias, and more
- Concepts with extensive illustrations and references for better understanding and clinical and research implementation
- Extensively illustrated with figures, tables, and clinical pathways to elucidate yoga's application in daily clinical practice
- Details yogic postures used in clinical trials to be used for prescribing yoga in different cardiovascular diseases



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