Meditation and Cardiovascular Risk Reduction
A Scientific Statement From the American Heart Association

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Abstract—Despite numerous advances in the prevention and treatment of atherosclerosis, cardiovascular disease remains a leading cause of morbidity and mortality. Novel and inexpensive interventions that can contribute to the primary and secondary prevention of cardiovascular disease are of interest. Numerous studies have reported on the benefits of meditation. Meditation instruction and practice is widely accessible and inexpensive and may thus be a potential attractive cost-effective adjunct to more traditional medical therapies. Accordingly, this American Heart Association scientific statement systematically reviewed the data on the potential benefits of meditation on cardiovascular risk. Neurophysiological and neuroanatomical studies demonstrate that meditation can have long-standing effects on the brain, which provide some biological plausibility for beneficial consequences on the physiological basal state and on cardiovascular risk. Studies of the effects of meditation on cardiovascular risk have included those investigating physiological response to stress, smoking cessation, blood pressure reduction, insulin resistance and metabolic syndrome, endothelial function, inducible myocardial ischemia, and primary and secondary prevention of cardiovascular disease. Overall, studies of meditation suggest a possible benefit on cardiovascular risk, although the overall quality and, in some cases, quantity of study data are modest. Given the low costs and low risks of this intervention, meditation may be considered as an adjunct to guideline-directed cardiovascular risk reduction by those interested in this lifestyle modality, with the understanding that the benefits of such intervention remain to be better established. Further research on meditation and cardiovascular risk is warranted. Such studies, to the degree possible, should utilize randomized study design, be adequately powered to meet the primary study outcome, strive to achieve low drop-out rates, include long-term follow-up, and be performed by those without inherent bias in outcome. (J Am Heart Assoc. 2017;6:e002218. DOI: 10.1161/JAHA.117.002218.)

Key Words: AHA Scientific Statements • cardiovascular disease • cardiovascular risk • meditation • primary prevention • secondary prevention

Despite numerous advances in the prevention and treatment of atherosclerosis, cardiovascular disease (CVD) remains a leading cause of morbidity and mortality in the United States1,2 and the developed world.3-5 Although educational, lifestyle modifying, and pharmacological interventions have lowered the prevalence of cardiovascular risk factors, most Americans still have at least 1 major risk factor.6,7 More than $200 billion are spent on care of patients with CVD in the United States annually, and this is expected to increase 2- to 3-fold over the next several decades.2,8 Accordingly, novel and inexpensive interventions that are of benefit to patients and

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Accompanying Tables S1 through S9 are available at http://jaha.ahajournals.org/content/6/9/e002218/DC1/embed/inline-supplementary-material-1.pdf


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can contribute to the primary and secondary prevention of CVD are of interest.

Dozens of studies have reported on the health benefits of meditation. According to the National Health Interview Survey, 8% of US adults practice some form of meditation.9 Up to 14% to 24% of patients with CVD have been reported to use or to have used some form of mind-body therapy, and 2% to 3% use or have used some form of meditation.10–13 In addition, half of CVD patients are interested in participating in a clinical trial of alternative therapies, and 17% are interested in participating in a clinical trial of meditation.10–13 Many forms of meditation can be learned from publications, the internet, and audio media. Many meditation courses are available for a modest fee or voluntary contribution. Hence, meditation may be an attractive cost-effective adjunct to more traditional medical therapies. Accordingly, the American Heart Association commissioned this scientific statement to systematically and scientifically review the data on the potential benefits of meditation related to CVD.

Methodology
Studies on meditation and cardiovascular risk reduction were searched for on PubMed using search terms including meditation, stress, blood pressure, hypertension, smoking, tobacco use, insulin resistance, metabolic syndrome, atherosclerosis, endothelial function, myocardial ischemia, primary prevention, and secondary prevention. Additional searches were performed on Google and Google Scholar, because some articles on meditation are not listed in PubMed.

Practices such as tai chi, qigong, and yoga, although involving inner focus and a concentration on breathing, consist of both mental and physical practices. Regular physical activity and exercise has itself been associated with cardiovascular risk reduction,14,15 and thus findings from such studies would be confounded. Therefore, this review was restricted to practices of sitting meditation.

For all sections examining the effects of meditation on aspects of cardiovascular risk, a primary author without relationships with industry and a secondary reviewer drafted the initial text and conclusions. All sections, tables, and conclusions were then reviewed by all writing group members and the manuscript revised based on this review. The manuscript was then reviewed by 4 external reviewers and revised accordingly. The finalized manuscript was approved by all writing group members.

Meditation
The practice of meditation dates as far back as 5000 BC.16 Although associated with Eastern philosophies and religion, including Buddhism and Hinduism, references or inferences regarding meditation and the meditative process can be found in Christianity, Judaism, and Islam.16 Over the past several decades, meditation is increasingly practiced as a secular and therapeutic activity.

In the traditional context, meditation refers to a family of mental practices that are designed to improve concentration, increase awareness of the present moment, and familiarize a person with the nature of their own mind.16 In a more general and contemporary context, meditation can be categorized as primarily focused attention, mindfulness, loving kindness and compassion, or mantra repetition, although there is usually overlap between the focuses.17–19 With focused attention (“samatha” meditation), the practitioner may focus on the breath or on an object, sound, sensation, visualization, thought, or repeated word or phrase (“mantra”). When the mind wanders, the meditator notices the mind wandering and learns to bring the mind back to the present moment or the object of meditation. In mindful meditation, the individual strives to be in the present moment and aware of internal sensations, thoughts, and external stimuli, without becoming engrossed in or distracted by them. Mindfulness-based stress reduction is a program based primarily on mindful meditation, as well as yoga; other mindfulness-based programs are similarly based on mindful meditation. Insight (“vipassana”) meditation can be considered a form of mindful meditation. In loving kindness and compassion, the meditator cultivates a feeling of benevolence toward oneself and others. In Vedic or transcendental meditation, repeated thought of a word is used to relax and clear the mind. The “relaxation response” technique similarly uses focused silent repetition of a word, sound, or phase. These practices may be used to: (1) increase concentration, insight, or awareness of the present moment; (2) promote relaxation; (3) reduce stress; (4) settle the mind; (5) achieve a state of increased consciousness; and (6) reduce perceived suffering and increase happiness.

Table 1 provides a summary of common types of meditation. Most forms of meditation are practiced ≥20 minutes or once or twice daily. Although meditation was first practiced millennia ago as part of Buddhist and Hindu religions, it has recently been introduced in the West as a stand-alone secular activity.

Neurophysiology and Neuroanatomy of Meditation
Almost 2 decades of scientific studies, conducted at ≥20 universities, have identified the effects of meditation on the brain.18 Most forms of meditation engage regions in the brain that regulate attention and emotion.29 The adult brain can undergo changes through a process called neuroplasticity, which may include development of new circuits (“rewiring”) and/or neurons.30 The different psychological targets of meditation are instantiated in distributed neural circuits that
Table 1. Common Types of Meditation

<table>
<thead>
<tr>
<th>Meditation</th>
<th>Description</th>
<th>Origins and Well-Known Teachers in the West</th>
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<tbody>
<tr>
<td>Samatha meditation</td>
<td>Samatha is translated to mean “calm” and samatha meditation is often referred to as calm, abiding meditation. Samatha meditation is the practice of calming the mind by practicing single-pointed meditation through mindful concentration focusing on the breath, image, or object.</td>
<td>Buddhist practice, dating to the time of the Buddha or even before</td>
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<tr>
<td>Vipassana meditation</td>
<td>Vipassana is translated to mean, “to see things as they really are.” Vipassana emphasizes awareness of the breath, tuning into the air passing in and out through the nose. Vipassana teaches one to label thoughts and experiences as they arise, taking mental notes as one identifies objects that grab one’s attention. Vipassana meditation is often taught at 10-day retreats.</td>
<td>Traditional Buddhist and Indian meditation. Well-known teachers include Mahasi Sayadaw, S.N. Goenka, Sharon Salzberg, Joseph Goldstein, Jack Kornfield, and Michael Stone</td>
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<tr>
<td>Mindful meditation</td>
<td>An umbrella term for the category of techniques used to create awareness and insight by practicing focused attention, observing, and accepting all that arises without judgment. This type of meditation is also referred to as “open monitoring,” in which one allows one’s attention to flow freely without judgment or attachment.</td>
<td>Origins come from Buddhist teaching. Well-known Western teachers include Jon-Kabat Zinn, Tara Brach, Sharon Salzberg, Joseph Goldstein, Jack Kornfield, and Pema Chodron</td>
</tr>
<tr>
<td>Zen meditation (zazen)</td>
<td>A type of meditation where one focuses one’s awareness on one’s breath and observes thoughts and experiences as they pass through the mind and environment. In some senses similar to Vipassana meditation, but with an emphasis on a focus of the breath at the level of the belly and on posture while sitting.</td>
<td>Buddhist meditation from Japan. Well-known teachers include Thich Nhat Hanh and Joan Halifax Roshi</td>
</tr>
<tr>
<td>Raja yoga meditation</td>
<td>Referred to also as “mental yoga,” “yoga of the mind,” or Kriya yoga. A practice of concentration to calm the mind and bring it to one point of focus. Includes a combination of mantra, breathing techniques, and meditation on the chakras/spinal cord focus points.</td>
<td>Hindu practice dating back thousands of years. Introduced to the West in 1893 by Swami Vivekananda. Further clarified and taught by Paramhansa Yogananda for the Western audience</td>
</tr>
<tr>
<td>Loving-kindness (metta)</td>
<td>Loving-kindness meditation involves sending loving kindness to oneself, then continuing to send it to a friend or loved one, to someone who is neutral in your life, to a difficult person, and then out to the universe. Through this practice, the meditator cultivates a feeling of benevolence toward oneself and others.</td>
<td>Originates from Buddhist teachings, mainly Tibetan Buddhism. Well-known instructors include Sharon Salzberg and Pema Chodron</td>
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<tr>
<td>Transcendental meditation</td>
<td>Mantra-based meditation technique in which each practitioner is given a personal mantra that is used to help settle the mind inward. Transcendental meditation is taught by certified teachers through a standard 4-day course of instruction. Transcendental meditation is practiced for 20 minutes twice daily.</td>
<td>Origins in ancient Vedic traditions of India. Popularized in the West by the Maharishi Mahesh Yogi and now taught in the United States by the Maharishi Foundation</td>
</tr>
<tr>
<td>Relaxation response</td>
<td>A multifaceted practice that can involve awareness and tracking of breaths or repetition of a word, short phase, or prayer.</td>
<td>A term and practice pioneered by Dr Herbert Benson in the 1970s, based in part of the practice of transcendental meditation</td>
</tr>
</tbody>
</table>

There is no definitive definition of most types of meditation. These descriptions represent a synthesis of numerous sources and are best viewed as a general overview of the techniques. Initial table concept from references 20 and 21. Additional data from references 16–19 and 22–28. Table adapted with permission from Rakel, Integrative Medicine, 3rd ed. Copyright Elsevier 2012.

include different sectors of the prefrontal cortex and anterior cingulate cortex, the insula, and the midline regions that are important in default mode function. In addition, studies of loving-kindness and/or compassion meditation practices often lead to alterations in subcortical circuits directly implicated in emotional processing, such as the amygdala and ventral striatum. Studies of the effects on meditation on the brain include those using electroencephalography, magnetic resonance imaging, and functional magnetic resonance imaging.

Whereas numerous studies have reported on the acute neurophysiological effects of meditation, more relevant to this scientific statement are long-term neurophysiological and neuroanatomical changes. In 1 of the first reports on the long-term effects of meditation on the brain, a 2-month mindfulness meditation program resulted in increased left-sided anterior brain electrical activation, a pattern associated with positive affect and emotion, whereas no such changes occurred in a wait-listed control group. A study of long-standing Buddhist meditation practitioners demonstrated...
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Effects of Meditation on Psychological, Psychosocial, and Physiological Responses to Stress

Numerous studies, across both healthy and disease-based populations, have explored the effects of meditation on psychological and psychosocial outcomes. Most published studies report some improvements in levels of perceived stress, mood, anxiety, depression, quality of sleep, or overall well-being. A meta-analysis of 21 studies examining ≈300 meditation practitioners found that meditation can have long-standing effects on the brain, which may have beneficial consequences on the physiological basal state, physiological responses, and cardiovascular risk. However, these studies generally were nonrandomized and involved modest numbers of participants, some of whom were highly experienced (>10,000 hours) meditators. Additionally, different forms of meditation (e.g., focused attention, mindfulness, and loving kindness) will have different psychological and neurological effects. Thus, the neurophysiological and neuroanatomical findings associated with 1 type of meditation cannot be extrapolated to all forms. Extrapolation of the findings in the aforementioned studies to the general population who engage in meditation must be done with caution.

Effects of Meditation on Blood Pressure

Few high-quality, randomized trials of meditation and lowering of blood pressure have been published (Table S2). The efficacy of mindfulness meditation for blood pressure reduction has been evaluated in a few studies. The HARMONY (Hypertension Analysis of Stress Reduction Using Mindfulness Meditation and Yoga) trial assessed 24-hour ambulatory blood
pressure measurements in patients with stage I hypertension randomized to an 8-week mindfulness-based stress reduction program or wait-list control and found no benefit of meditation.\textsuperscript{63} In contrast, in a pilot study of 83 predominantly hypertensive blacks randomized to a mindful meditation program or control social support group, an 11/4 mm Hg decrease in systolic/diastolic blood pressure was observed in those randomized to 8 weeks of treatment and an analysis-adjusted 22/17 mm Hg difference in blood pressure between the 2 groups at follow-up.\textsuperscript{64} Of note, this trial had 100% data ascertainment, over 80% compliance at each clinic visit, and measured blood pressure with an unattended manual device (a rigorous protocol with measurements 7–15 mm Hg lower than typical office readings). Other mind-body interventions that

### Table 2. Summary of Findings on Studies of Meditations and Cardiovascular Risk Reduction*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Findings</th>
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| Neurophysiology and neuroanatomy           | • Neurophysiological and neuroanatomical studies suggest that meditation can have long-standing effects on brain physiology and anatomy  
• Studies generally are nonrandomized and involve modest numbers of participants, sometimes performed under the direction of extremely experienced (>10 000 hours) meditators  
• Different forms of meditation have different psychological and neurological effects, and thus the neurophysiological and neuroanatomic findings of 1 type of meditation cannot be extrapolated to other forms of meditation |
| Psychological, psychosocial, and physiological response to stress | • Many, although not all, studies report that meditation is associated with improved psychological and psychosocial indices  
• Differences in populations, control of potential confounders, and type and length of meditation evaluated may account for discrepant findings. Small sample sizes and lack of randomization are common study limitations  
• Further study is needed on how meditation influences physiological processes associated with the stress response |
| Blood pressure                             | • Magnitude of reductions of systolic blood pressure varies widely  
• Study limitations including the methods of blood pressure measurements and bias in data ascertainment, high dropout rates, and different populations studied |
| Smoking and tobacco use                     | • Some randomized data show that mindful meditation instruction improves smoking cessation rates |
| Insulin resistance and metabolic syndrome   | • Limited data on the effects of meditation on insulin resistance and metabolic syndrome |
| Subclinical atherosclerosis                 | • A few suboptimal studies of meditation and lifestyle intervention suggest the potential for benefit on atherosclerosis regression  
• Studies limited by multimodality approach, attrition, and incomplete follow-up  
• No firm conclusions can be drawn on the effects of meditation on atherosclerosis |
| Endothelial function                       | • Three studies showed no benefit of meditation on brachial reactivity in the overall cohorts, although 1 study suggested a benefit in a subgroup of patients with coronary artery disease  
• No conclusions can be drawn on the effects of meditation on endothelial function |
| Inducible myocardial ischemia              | • Limited older studies suggest that meditation can lead to improvement in exercise duration and decreased myocardial ischemia  
• No contemporary studies have evaluated effects of meditation on myocardial blood flow or ischemia with advanced imaging techniques |
| Primary prevention of CVD                  | • Two studies of short-term intervention report surprising mortality reductions, and thus these findings need to be reproduced in larger, multicenter studies  
• Overall, because of the limited evidence to date, no conclusions can be drawn as to the effectiveness of meditation for the primary prevention of CVD |
| Secondary prevention of CVD                | • Data on the potential benefits of meditation in patients with established coronary artery disease can best be characterized as generally of modest quality and as suggesting, but not definitely establishing, benefit  
• Because of generally limited follow-up time, there are more data on reduction of cardiac risk factors and psychological indices than on hard end points (eg, death, myocardial infarction) |

*Summaries of the individual studies, as well as their limitations, evaluated in this scientific statement are provided in Tables S1 through S9. CVD indicates cardiovascular disease.
The effects of transcendental meditation on blood pressure have also been reported.70–73 A study of 298 university students randomized to transcendental meditation or wait-list control found at 3-month follow-up no significant changes in systolic or diastolic blood pressure, although significant reductions in blood pressure (5/3 mm Hg, respectively) did occur in those at high risk of the development of hypertension.71 In a randomized study of stress reduction in 201 black men and women with angiographically documented coronary artery disease randomized to transcendental meditation or health education, 5.4-year follow-up found a 4.9 mm Hg lower systolic blood pressure, 1 of numerous secondary study end points, in those randomized to transcendental meditation than in those randomized to health education, primarily because of an increase in blood pressure in the health education group.70

Numerous systematic reviews have been conducted on the effects of meditation on blood pressure. One 2007 systematic review assessed several methods of stress reduction in patients with hypertension and found modest benefit (ie, 5/3 mm Hg systolic/diastolic blood pressure reduction) with transcendental meditation; other popular types of meditation were not assessed.74 Numerous meta-analyses in a 2007 Agency for Healthcare Research and Quality report on meditation and health generally found modest to no significant benefit with different meditation techniques when compared with active control groups (eg, health education), though the report also stated that meta-analyses based on low-quality studies and small numbers of hypertensive participants showed that transcendental meditation and Zen Buddhist meditation significantly reduced blood pressure.75 A 2013 American Heart Association scientific statement on alternate approaches to lowering blood pressure concluded that transcendental meditation modestly lowers blood pressure and that its use may be considered.76 The writing group also concluded at that time that there were insufficient high-quality studies assessing the benefit of other forms of meditative techniques to recommend them for blood pressure lowering. A 2015 analysis of 12 randomized, clinical trials of transcendental meditation involving a total of 996 predominantly black patients with or without hypertension found a mean reduction in blood pressure of 4/2 mm Hg (systolic/diastolic) over the study duration of 2 to 60 months (mean 4 months) when compared with control participants.72 Benefit in systolic blood pressure reduction seemed to persist up to 12 months.70–73,76 Of note, the completion rate (percentage of patients who completed all training and post-test) in these studies was a modest 63%.

The mechanism(s) whereby meditation lowers blood pressure when it occurs has not been fully elucidated.77 Possibly, the long-term neurophysiological changes that occur with meditation35–37,78 may lead to autonomic nervous system–mediated changes in blood pressure. One study of 15 participants with hypertension and chronic kidney disease reported a decrease in muscle sympathetic nerve activity and blood pressure during mindfulness meditation,79 but no such long-term data exist. The impact of stress reduction on blood pressure remains to be better defined.

Reported reductions of systolic blood pressure with meditation vary widely. The heterogeneity in results reflects the various study populations, study designs, data ascertainment protocols, study duration, baseline blood pressure, and blood pressure measurement techniques used. Limitations to clinical interpretation include high drop-out rates, bias in data ascertainment, and lack of attention to statistical power, control participants, and methods of blood pressure measurements.46,80 The ability to generalize the findings is limited by the lack of reproducibility of results.

Effects of Meditation on Smoking and Tobacco Use

Cigarette smoking is the leading cause of preventable disease and deaths in the United States, accounting for >480 000 deaths every year, or 1 of every 5 deaths.81,82 Two thirds of American adults want to quit smoking, and yet only ≈6% achieve this goal annually.83 Several types of meditation have been studied as interventions to facilitate smoking cessation (Table S3). Small studies84–89 have shown that mindfulness training, a form of meditation, increases abstinence rates when compared with more traditional intervention programs. In 1 study of volunteers wishing to reduce stress, half of whom were smokers, who were randomized to either a 2-week program of integrative body-mind technique—a form of mindfulness meditation—or relaxation training, a 60% reduction in smoking was observed among those instructed in integrative body-mind technique, with no reduction in those instructed in relaxation training. In this study, resting-state brain scans before and after intervention showed increased activity in the anterior cingulate and prefrontal cortex—areas of the brain that are related to self-control—for the meditation group, but not the relaxation training group.90 A meta-analysis of 4 randomized, controlled trials of mindfulness training involving a total of 474 patients found that it was more effective than group counseling, with 25% of mindfulness training participants remaining abstinent from smoking for >4 months, compared with 14% of those receiving more-traditional cessation instruction.91 One study of transcendental meditation in 295 college students found no significant reduction in cigarette smoking at 3-month follow-up between
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Effects of Meditation on Insulin Resistance and Metabolic Syndrome

Metabolic syndrome, a cluster of conditions including hypertension, dyslipidemia, elevated fasting blood glucose, and abdominal obesity, is a risk factor for diabetes mellitus and CVD.93–95 Data on the effects of meditation on insulin resistance and metabolic syndrome are sparse (Table S4). In a study of 103 patients with coronary artery disease randomized to transcendental meditation or active control (health education), transcendental meditation improved insulin resistance.96 A study of the effects of meditation, yoga, and a vegetarian diet on parameters of metabolic syndrome97 was too confounded by the multimodality approach to draw meaningful conclusions.

The relaxation response—the counterpart of the stress response—can be evoked by meditation. In 1 novel study,98 20 minutes of listening to a relaxation response instructional CD reduced expression of genes linked to inflammatory response and the stress-related pathway—mechanisms that contribute to metabolic syndrome99,100—and enhanced expression of genes associated with energy metabolism, mitochondrial function, and insulin secretion. Changes in gene expression were more pronounced in experienced practitioners of relaxation techniques than in novices who had recently undergone 8 weeks of relaxation response training. The clinical effects of these changes in gene expression, if any, remain unknown.

A comprehensive review of metabolic syndrome and mind-body therapies identified only 3 relevant clinical trials, 2 of which are discussed above and the third of which involved restorative yoga as the primary intervention.101 In summary, data on the effects of meditation on insulin resistance and metabolic syndrome are limited.

Effects of Meditation on Subclinical Atherosclerosis

Limited evidence exists for the effects of meditation on subclinical atherosclerosis (Table S5). Only 1 randomized, controlled trial was identified that studied the effects of a meditation intervention on atherosclerosis progression.102 In this study, carotid intimal thickness was assessed in 138 hypertensive blacks randomized to a transcendental meditation or control health education program and followed for a mean of 7 months. Attrition was high, with 57% of participants not completing follow-up. Among completers of the study, carotid intimal thickness regression was noted in the meditation group, whereas progression occurred in controls, with the difference between the 2 groups being statistically significant. In another randomized study, 57 healthy adults aged ≥65 years were randomized to 1 of 3 interventions: a transcendental meditation program that also included diet, exercise, and vitamin treatment; a diet/exercise/vitamin arm without the meditation component; or a usual care arm.103 At 1 year, the meditation intervention group showed reduction in carotid intimal thickness that was not observed in the other groups.

Other studies on subclinical atherosclerosis evaluated more comprehensive multimodality lifestyle interventions that generally included components of dietary changes, exercise, and stress management (including components of meditative practice).104–107 Study end points included changes in coronary artery atherosclerosis as assessed by quantitative coronary angiography104–106 and ankle-brachial indices.107 Although these studies showed favorable effects of lifestyle intervention on atherosclerosis regression, given the multimodality approach, it is difficult to discern the effects of the meditation component alone. Study result interpretation is also limited by attrition and incomplete follow-up. In summary, although a few studies of meditation and lifestyle intervention suggest the potential for benefit on atherosclerosis progression, no firm conclusions can be made on the effects of meditation alone on atherosclerosis.

Effects of Meditation on Endothelial Function

Endothelial function can be indirectly assessed by evaluating brachial artery endothelial vasomotor response. In a pilot study of 41 participants (33 of whom completed the study), a 6-week combined yoga and meditation intervention failed to significantly improve endothelial function, although there was improvement in the cohort of 10 patients with coronary artery disease.108 In a trial of 103 patients with coronary artery disease (84 of whom completed follow-up) randomized to 16 weeks of transcendental meditation or control health education, meditation had no significant effect on brachial artery reactivity testing.76 In a trial of 68 black Americans with metabolic syndrome risk factors, consciously resting meditation improved flow-mediated dilation at 12-month follow-up, but compared with changes in the control...
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health-education group, this improvement was not significantly different.106 Only 38 participants (56%) completed the 12-month follow-up.

Limitations of these studies variably include modest sample size, relatively short durations of intervention, high attrition rates, and incomplete follow-up (Table S6). Given these factors, as well as the different patient populations studied and variable findings in those with established coronary artery disease, no definitive conclusions on the effects of meditation on endothelial function can be made.

Effects of Meditation on Inducible Myocardial Ischemia

A paucity of studies has examined the effects of meditation on inducible myocardial ischemia (Table S7). In a 1996 study of 21 participants with coronary artery disease, 7.6 months of transcendental meditation led to significant increases in exercise duration (15%) and maximal workload (12%) compared with wait-listed controls, as well as lower rate-pressure products at given workloads and significantly delayed onset of ST depression.110 In a 1983 study of 46 patients with ischemic heart disease that combined stress management (meditation and stretching/relaxation exercises) and a vegan-based diet, after 24 days those randomized to the lifestyle-intervention group had a 44% increase in exercise duration, 55% increase in total work, and improved exercise ejection fraction and regional wall motion, whereas no significant changes occurred in those randomized to the control group.111

No contemporary studies have evaluated the impact of meditation on myocardial blood flow or ischemia with techniques such as stress echocardiography, single-photon emission computed tomography, cardiac positron emission tomography, or cardiac magnetic resonance imaging. Larger, randomized, clinical studies that evaluate the impact of meditation-based interventions on inducible myocardial ischemia, ideally using more sophisticated modalities to assess and quantify ischemia, are needed.

Meditation and Primary Prevention of CVD

Although studies have assessed the effect of meditation on cardiovascular risk factors, recent Cochrane reviews112–115 have concluded that no properly conducted randomized, controlled trials have assessed its role in the primary prevention of cardiovascular mortality or nonfatal primary end points. This is largely because the relevant studies are small, with short-term follow-up and carried out in predominantly healthy participants.

One study116 measured survival rate in 73 elderly participants randomly assigned to 3 months of transcendental meditation, mindfulness training, mental relaxation, or a no-treatment control group. The survival rate after 3 years for the transcendental meditation group was significantly better; 100% compared with 65% to 87% for other groups. In a second study, mortality and cause of death were assessed from vital statistics over 8 years of follow-up in 109 older black patients who had participated in a hypertension study. Participants were randomly assigned to 2 stress reduction approaches—either transcendental meditation or progressive muscle relaxation—or to a health education (ie, control) group for 3 months. The adjusted relative risk for CVD mortality was significantly reduced by 81% in the transcendental meditation group when compared with the control group.117 In both studies, mortality was assessed 3 to 8 years after the intervention period, so the results may not be attributed to transcendental meditation. This and other methodological issues raise concerns about the validity of their findings.

When patient data from the abovementioned 2 randomized, controlled trials were combined in a post-hoc analysis,8 the transcendental meditation group reportedly showed a 23% reduction in all-cause mortality compared with the control patients, a 30% reduction in cardiovascular mortality, and a nonstatistically significant 51% reduction in rate of cancer mortality (Table S8). These studies of short-term intervention applied to a limited number of participants report surprising mortality reductions that are on par with, or greater than, those observed in long-term intervention, large-scale, primary prevention studies of cholesterol therapy118 and of blood pressure reduction.119,120 Accordingly, these findings need to be reproduced in larger, multicenter studies.

In summary, data regarding the effectiveness of meditation for primary prevention of CVD are lacking, and because of the limited evidence to date, no conclusions can be drawn as to the effectiveness of meditation for the primary prevention of CVD.

Meditation and Secondary Prevention of CVD

Limited and limited-quality data are available from studies of meditation for secondary prevention of CVD (Table S9). Such studies, which generally have enrolled patients with stable coronary artery disease, have variably reported reductions in systolic blood pressure, insulin resistance, serum lipids, clinical symptoms, and anxiety and stress.70,96,106,110,121–127 Most, although not all, studies randomized patients to either meditation or some type of “usual care.” These studies are generally limited by modest sample size and limited duration
follow-up, and a few assessed multifactorial interventions that combined meditation with other interventions (ie, yoga, diet). A systematic review and meta-analysis of randomized, controlled trials of mind-body practices, including meditation but other interventions as well, found that such interventions were associated with improvements in physical and mental quality of life, depression and anxiety, and systolic and diastolic blood pressure, but rated the overall quality of the studies as low.\textsuperscript{128}

One commonly cited study involves 201 patients with angiographically documented coronary artery disease randomized to transcendental meditation or health education.\textsuperscript{70} After a mean of 5.4 years, the primary composite end point of all-cause mortality, nonfatal myocardial infarction, or nonfatal stroke was significantly lower in the meditation group (adjusted hazard ratio, 0.52). Post-hoc analysis found greater benefit (hazard ratio, 0.34) in those with high adherence. There was a nonsignificant 24\% reduction in the broader secondary composite endpoint, which also included coronary revascularization or hospitalization for cardiac causes. The study, though, was conducted in 2 phases after a 1-year hiatus with 58 patients not participating in phase 2 of the study, and some concerns about analysis of the data have been raised.\textsuperscript{129,130}

Overall, data on the potential benefits of meditation in patients with established coronary artery disease can best be characterized as of modest quality and suggesting, but not definitely establishing, benefit in secondary prevention. Because of the generally limited follow-up time, more data on reduction of cardiac risk factors and psychological indices (eg, stress, anxiety, and depression) exist than on hard end points (eg, death or myocardial infarction).

Summary

Studies of meditation to date suggest a possible benefit on cardiovascular risk reduction. A 2008 review of >400 trials of meditation and health care rated the methodological quality of clinical trials as poor, but noted that the quality of these trials had significantly improved over time.\textsuperscript{80} Methodological issues in research to date include modest study size, limited and often incomplete follow-up, high drop-out rates, lack of randomization and/or appropriate control group, and unavoidable patient non-randomized studies. As with many other novel interventions, there is the possibility of publication bias toward positive studies of the beneficial effects of meditation.\textsuperscript{37,38} Many investigators who conducted studies of meditation may have a strong belief in the benefits of meditation and may be enthusiastic meditators themselves,\textsuperscript{37} thereby introducing the possibility of unintended bias. Many studies of meditation techniques are performed by the same groups of researchers, so there is a need for independent verification of reported positive findings. Whereas these studies are important in that they serve to suggest that meditation may reduce cardiovascular risk, these limitations prevent definitive conclusions regarding efficacy of meditation on cardiovascular risk reduction.

Currently, the mainstay for primary and secondary prevention of CVD is ACC/AHA guideline-directed interventions. However, considering the generally low costs and risks associated with meditation, meditation may be considered as a reasonable adjunct to guideline-directed cardiovascular risk reduction by those interested in this lifestyle modification with the understanding that the benefits of such intervention remain to be better established.

Further research on meditation and cardiovascular risk is warranted. Such studies, to the degree possible, should utilize randomized study design, be adequately powered to detect clinically meaningful benefit, include long-term follow-up, and be performed by those without inherent bias in outcome. One such example is the ongoing Yoga-CaRe study for secondary prevention of myocardial infarction.\textsuperscript{131} A summary of findings on meditation and cardiovascular risk reduction and on suggested methodology for future research are given in Table 3.

### Table 3. Summary of Findings and Suggestions on Meditation and Cardiovascular Risk Reduction

- Studies of meditation suggest a possible benefit on cardiovascular risk, although the overall quality and, in some cases, quantity of study data is modest.
- The mainstay for primary and secondary prevention of CVD is ACC/AHA guideline-directed interventions.
- Meditation may be considered as an adjunct to guideline-directed cardiovascular risk reduction by those interested in this lifestyle modification with the understanding that the benefits of such intervention remain to be better established.
- Further research on meditation and cardiovascular risk is warranted. Such studies, to the degree possible, should meet the following criteria:
  - Utilize a randomized study design.
  - Blinded adjudication of end points.
  - Adequate power to meet the primary study outcome(s).
  - Include long-term follow-up.
  - Have <20\% dropout rate.
  - Have >85\% follow-up data.
  - Be performed by investigators without inherent financial or intellectual bias in outcome.

ACC indicates American College of Cardiology; AHA, American Heart Association; CVD, cardiovascular disease.
### Disclosures

#### Writing Group Disclosures

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<tr>
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*Modest.
†Significant.

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## References


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