REVIEW ARTICLE

Yoga and Hypertension: A Systematic Review

Anupama Tyagi, MA, PhD(c); Marc Cohen, MBBS(Hons), PhD, BMedSc(Hons), FAMAC, FICAE

ABSTRACT

Lifestyle modification is a cornerstone of hypertension (HPT) treatment, yet most recommendations currently focus on diet and exercise and do not consider stress reduction strategies. Yoga is a spiritual path that may reduce blood pressure (BP) through reducing stress, increasing parasympathetic activation, and altering baroreceptor sensitivity; however, despite reviews on yoga and cardiovascular disease, diabetes, metabolic syndrome, and anxiety that suggest yoga may reduce BP, no comprehensive review has yet focused on yoga and HPT. A systematic review of all published studies on yoga and HPT was performed revealing 39 cohort studies, 30 nonrandomized, controlled trials (NRCTs), 48 randomized, controlled trials (RCTs), and 3 case reports with durations ranging from 1 wk to 4 y and involving a total of 6693 subjects. Most studies reported that yoga effectively reduced BP in both normotensive and hypertensive populations. These studies suggest that yoga is an effective adjunct therapy for HPT and worthy of inclusion in clinical guidelines, yet the great heterogeneity of yoga practices and the variable quality of the research makes it difficult to recommend any specific yoga practice for HPT. Future research needs to focus on high quality clinical trials along with studies on the mechanisms of action of different yoga practices. (*Altern Ther Health Med.* 2014;20(2):32-59.)

Anupama Tyagi, MA, is a PhD candidate at the Royal Melbourne Institute of Technology (RMIT) University School of Health Sciences in Bundoora, Australia. Marc Cohen, MBBS (Hons), PhD, is a professor at the RMIT University School of Health Sciences.

Corresponding author: Marc Cohen, MBBS(Hons), PhD, BMedSc(Hons), FAMAC, FICAE
E-mail address: marc.cohen@rmit.edu.au

Hypertension (HPT), which is defined as a persistently high blood pressure (BP) with systolic blood pressure (SBP) ≥ 140 and diastolic blood pressure (DBP) ≥ 90, is a major public health issue that is estimated to affect more than 1 billion people worldwide and account for 13% of deaths, 64 million disability-adjusted life years, and 7 million premature deaths per year.[1,2] By the year 2025, it is estimated that approximately 1 in 3 adults aged over 20 years, or 1.56 billion people worldwide, will have HPT.[3]

The relationship between HPT and the risk of cardiovascular events, stroke, and kidney disease is continuous, consistent, and independent of other risk factors.[4-7] Beginning at 115/75 mm Hg, each incremental rise of 20/10 mm Hg in BP substantially increases the risks of mortality and morbidity in cerebrovascular and cardiovascular disease (CVD),[4,8-10] while treating raised BP is associated with a 35% to 40% reduction in the risk of stroke and a 16% reduction in the risk of myocardial infarction.[2]

Pharmacological interventions for HPT are used routinely, yet the critical importance of nonpharmacological approaches and lifestyle modifications has continued to be recognized and recommended by expert panels on HPT.[4,11] Lifestyle modifications may prevent HPT in prehypertensive individuals, serve as primary therapy in hypertensive participants before the start of drug therapy, and act as an adjunct to drug therapy for those already on medication.[12] It is reported that lifestyle modification alone can reduce SBP from 3 mm Hg to 32 mmHg and DBP from 2 mm Hg to 18 mm Hg.[13] A 1982 meta-analysis of 37 studies on the nonpharmacological treatment of HPT found that nonpharmacological treatments such as yoga, weight reduction, and muscle relaxation produced stable reductions in BP over 3 to 12 months, suggesting that they are credible alternatives to pharmacotherapy.[14]

A wealth of evidence now suggests that bidirectional interactions between the brain and peripheral tissues con-

tribute to both mental and physical health and that a rise in BP is a part of the fight-and-flight response that is associated with aggression, anxiety, tension, excitement, and anticipation in stressful situations.[15] Substantial evidence also indicates that psychological stress and sympathetic activation is a major risk factor for HPT, coronary artery disease (CAD), and cardiovascular mortality[16-20] and that individuals who exhibit exaggerated cardiovascular response to mental stress are at increased risk for developing HPT in subsequent years.[21,22] It has also been hypothesized that autonomic balance may be restored through mind-body practices that elicit the relaxation response and that reduce sympathetic and increase parasympathetic activity, such as yoga and meditation.[23] Other evidence suggests that yoga improves autonomic stability in hypertensive and diabetic participants.[24]

Yoga as a Nonpharmacological Mind-Body Intervention

Yoga is an ancient Indian system for integrating mind and body that is claimed to bestow the practitioner with physical, mental, intellectual, and spiritual development. Yoga encompasses many different paths including *karma* yoga (service), *bhakti* yoga (devotion), *jnana* yoga (knowledge), and *raja* (8 limb path of *patanjali*). *Hatha* yoga, which is the most commonly practiced yoga in the West, emerged from raja yoga and includes a diverse range of mind-body practices such as meditation/relaxation techniques (*dhayana*), breathing practices (*pranayama*), and physical postures (*asana*).[25]

Researchers have postulated that yogic relaxation and breathing techniques may reduce BP by inducing slow rhythmic proprioceptive and exteroceptive impulses, reducing peripheral adrenergic activity,[26] and facilitating autonomic balance,[27] which reduces chemoreceptor responses and enhances baroreflex sensitivity.[28-30] Yoga breathing and relaxation practices are commonly performed as an integrated practice that also includes physical postures, and such practices have been used to reduce BP[31] and positively affect other CVD risk factors, such as obesity,[32] lipid profile,[33] and glycemic control.[34]

In recent years, hatha yoga has become increasingly popular for dealing with stress, improving quality of life, treating a number of psychiatric and psychosomatic disorders, and improving psychological function.[31] Yoga practices are now advocated for the symptomatic treatment of stress-induced disorders such as insomnia,[35] anxiety,[36] depression,[37] and bronchial asthma.[38-40] Yoga has also been found to improve physiological functions such as carbohydrate metabolism,[41] lipid profile, and BP.

Reviews of Yoga and Clinical Conditions

Recent systematic reviews attest to the efficacy of yoga as a symptomatic treatment for several medical conditions, including (1) cancer,[42] (2) arthritis,[43] (3) anxiety,[44,45] (4) depression,[46,47] (5) back pain,[48,49] (6) respiratory problems,[50] and (7) menopausal symptoms.[51] Many clinical studies and a number of systematic reviews also have been performed on yoga and cardiovascular disorders,[52] coronary heart disease,[53] and cardiovascular risk factors such as diabetes.[54,55]

A number of general reviews have examined the effects of yoga-type interventions on BP. An exhaustive review and meta-analysis of 813 meditation studies, funded by the National Institutes of Health (NIH) and the National Center for Complementary and Alternative Medicine (NCCAM), noted that some meditation practices did produce significant changes in BP, although the studies' quality was generally poor and the interventions uncertain. A subgroup meta-analysis of 5 studies, totalling 201 healthy participants, found that yoga produced modest reductions in BP.[56] Another comprehensive meta-analysis of 105 randomized, controlled trials (RCTs), involving 6805 hypertensive participants and a wide range of lifestyle interventions, found that relaxation techniques, including yoga, produced reductions in BP of around 4/3.1 mm Hg.[57] A further meta-analysis of 17 RCTs on stress reduction approaches, involving 960 hypertensive participants, reported significant reductions in BP with meditation techniques.[58] Another meta-analysis of 25 RCTs examining the benefits of relaxation therapies that involved 1198 participants, however, concluded there is only weak evidence that relaxation therapies produce meaningful BP reductions in hypertensive patients.[59]

Yoga, Cardiovascular Disease, and Metabolic Syndrome

A number of reviews that examined the use of yoga for people with heart disease and metabolic syndrome have included data on the effects of yoga on BP. A review of 13 studies on the efficacy of yoga in the primary and secondary prevention of ischemic heart disease suggested a definitive role for yoga[53]; however, a subsequent systematic review of 6 RCTs of yoga for coronary risk factors concluded there was strong evidence for the benefits of yoga in the prevention and treatment of coronary heart disease in conjunction with normal medication, but that the evidence yoga alone led to reductions in BP was poor.[60]

A more comprehensive, systematic review of 70 studies, including 1 observational study, 26 uncontrolled trials, 21 nonrandomized controlled trials (NRCTs), and 22 RCTs, found beneficial effects for yoga for people with metabolic syndrome.[52] A subset analysis of 37 studies that examined yogic interventions and BP found that yoga practice was helpful in producing short-term reductions in BP in individuals with metabolic syndrome.[52] A further review of 32 studies from 1980 to 2007 found evidence for the efficacy of yoga in reducing BP as well as significant reductions in cholesterol, body weight, and blood glucose.[61] Similarly, Innes and Vincent reviewed 25 published studies and found that yoga improved risk indices of non–insulin-dependent diabetes mellitus (NIDDM), including glucose tolerance, insulin sensitivity, lipid profiles, anthropometric measures, and BP.[55]

A recent analysis of 5 RCTs examining yoga, including 363 participants, revealed a prominent lowering of plasma glucose and lipid profile and short-term benefits with yoga practice for individuals with NIDDM, but the studies were

generally of low quality and did not report a long-term follow-up.[54] A more recent systematic review of 3 RCTs of 228 individuals with metabolic syndrome reported that meditation and yoga reduced disease symptoms and improved clinical indicators of the syndrome.[62] More recently, 2 reviews attest to the benefits of yoga as a treatment for HPT. One reviewed the benefits of yoga for HPT in 19 studies published between the years 1972 and 2012, with 902 participants. This review reported that yoga was less costly than pharmacological therapies and, despite there being very few RCTs, suggested that yoga may serve as alternate to drugs in controlling HPT.[63] Another review of 6 RCTs and 1 cohort study on yoga and HPT, published from 2006 to 2011, involved 714 normotensive and hypertensive participants and revealed that a diversity of yoga practices were consistently effective in reducing blood glucose, blood cholesterol, and body weight.[64]

While many clinical trials on yoga and HPT and multiple reviews of yoga for cardiovascular risk factors and metabolic syndrome have been published, the literature on yoga and HPT has not yet been the subject of a comprehensive systematic review. The following review attempts to document published studies on yoga and BP and explore the current evidence for specific practices and potential underlying mechanisms.

METHODS

The authors conducted a thorough primary search for published medical literature, using the terms yoga, yogic, *shavasana, pranayama,* breathing, or breath, with the acronyms BP or HPT. Studies for this review were identified by a systematic cross search in the scientific databases Scopus, PubMed, PsycINFO, CINAHL, and ScienceDirect. Since yoga had its origins in the Indian subcontinent and a significant body of literature has been published in Indian medical journals, the databases IndMED and medIND, which include bibliographical details from 75 of the major Indian medical journals, were also searched thoroughly. Similarly, an electronic version of *Yoga Mimamsa,* which includes published literature on yoga research dating back to 1920 and which was not listed in the above databases, was also searched—as were the archives of the *International Journal of Yoga.*

All studies that evaluated BP as a primary or secondary outcome for yoga or yoga-type interventions were included. The search was not restricted by date or specific demographic or disease group and included all study types, including RCTs, NRCTs, cohort studies, and case studies. Studies were classified according to the type of intervention—yogic relaxation, slow breathing, integrated yoga practices, yoga, biofeedback, and use of the RESPeRATE device (InterCure Ltd, New York, NY, USA).

The authors included studies if they involved any specific component of yoga as well as all studies with a yoga-type intervention, such as slow, relaxed, focused breathing or yogic meditation like *bhrama kumari, ananda marg,* raja yoga, *om* meditation, *mantra* meditation, *sahaj* yoga meditation, *sudershan kriya* yoga, or *kundalini* yoga. Studies on other types of meditation such as Transcendental Meditation, mindfulness meditation, and zen meditation were excluded. Studies on yoga and biofeedback and the RESPeRATE device were included because of the slow, mindfulness-based breathing and/or relaxation techniques, which are in line with yogic interventions. Studies were also excluded if they (1) were not in English (n = 187), (2) were unobtainable (n = 12), (3) were in press (n = 1), (4) only documented a study protocol (n = 3), (5) did not have any specific component of either yoga or yoga-type breathing, or (6) included relaxation techniques other than yoga *nidra* or yogic relaxation, such as autogenic relaxation and progressive muscle relaxation. Experimental and laboratory studies that examined the transient physiological effects of yoga on BP (n = 13) and/or BP responses to acute stress were also excluded (n = 8) and will be the subject of a separate review. It was beyond the scope of this review to critically assess the methodological quality of all included studies; however, this review notes results and significance in the relevant text and tables.

RESULTS

A total of 120 studies were located that met the inclusion criteria as outlined in Figure 1. These included 39 cohort studies, 30 NRCTs, 48 RCTs, and 3 case reports on relaxation, breathing, integrated yoga techniques, biofeedback, and the RESPeRATE device. Studies had durations from 1 week to 4 years of follow-up, with numbers of participants ranging from 1 to 428. The total population assessed in these studies was 6693, including both healthy and disease populations involving 389 elderly and 299 adolescent participants. In total, the reviewed studies included 2415 hypertensive individuals, 60 with HIV, and 213 with NIDDM as well as 1083 people with metabolic syndrome and CVD risk factors.

The reviewed studies are presented in Tables 1 to 10 and have been divided according to the type of yogic intervention and the study's design. Tables 1 and 2 summarize 11 studies—4 cohort and 6 controlled trials—on yogic relaxation. Tables 3 and 4 summarize 17 studies—6 cohort and 11 controlled trials—on yogic breathing. Tables 5 and 6 summarize 33 studies—11 cohort and 22 controlled trials—on integrated yoga practices. Table 7 and 8 summarize 30 studies—12 cohort and 18 controlled trials—on integrated yoga practices for cardiovascular risk factors. Table 9 summarizes 17 studies—2 case reports and 4 cohort and 11 controlled trials—on yoga and biofeedback, and Table 10 summarizes 12 studies—1 case report and 2 cohort and 9 controlled trials—on yogic-style breathing facilitated by the RESPeRATE device.

The 48 RCTs reviewed have been represented in Figure 2, which indicates the study's type of yoga intervention, sample size, duration, and outcome (ie, whether or not the results showed a change in BP).

Yogic Relaxation Cohort Studies

One of the earliest published cohort studies reported that 3 weeks of shavasana practice resulted in significant

Figure 1. Flowchart of Study Search and Included Studies

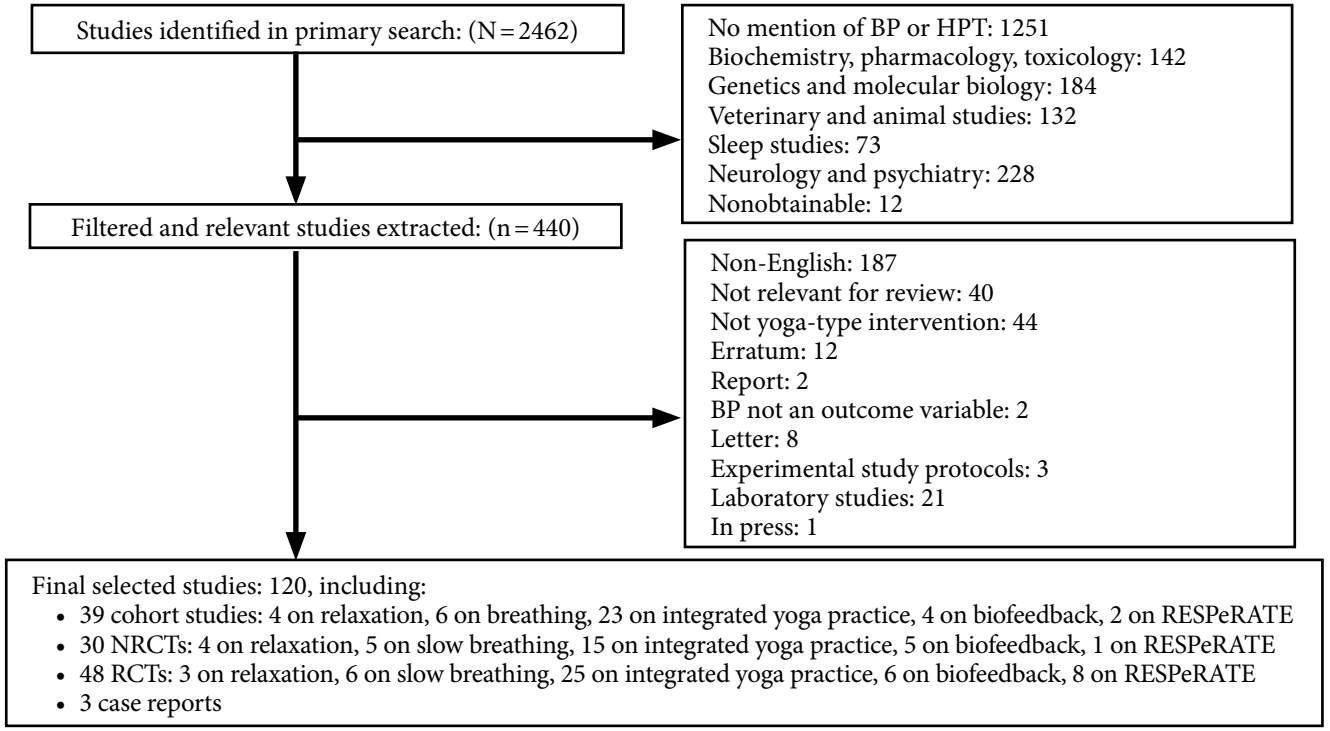

Figure 2. Summary of RCTs of Yoga and HPT

Studies are categorized according to (1) type of yogic intervention, (2) direction of result—change or no change in BP, (3) sample size—box height, (4) duration—box width, and (5) length of follow-up—shaded box width.

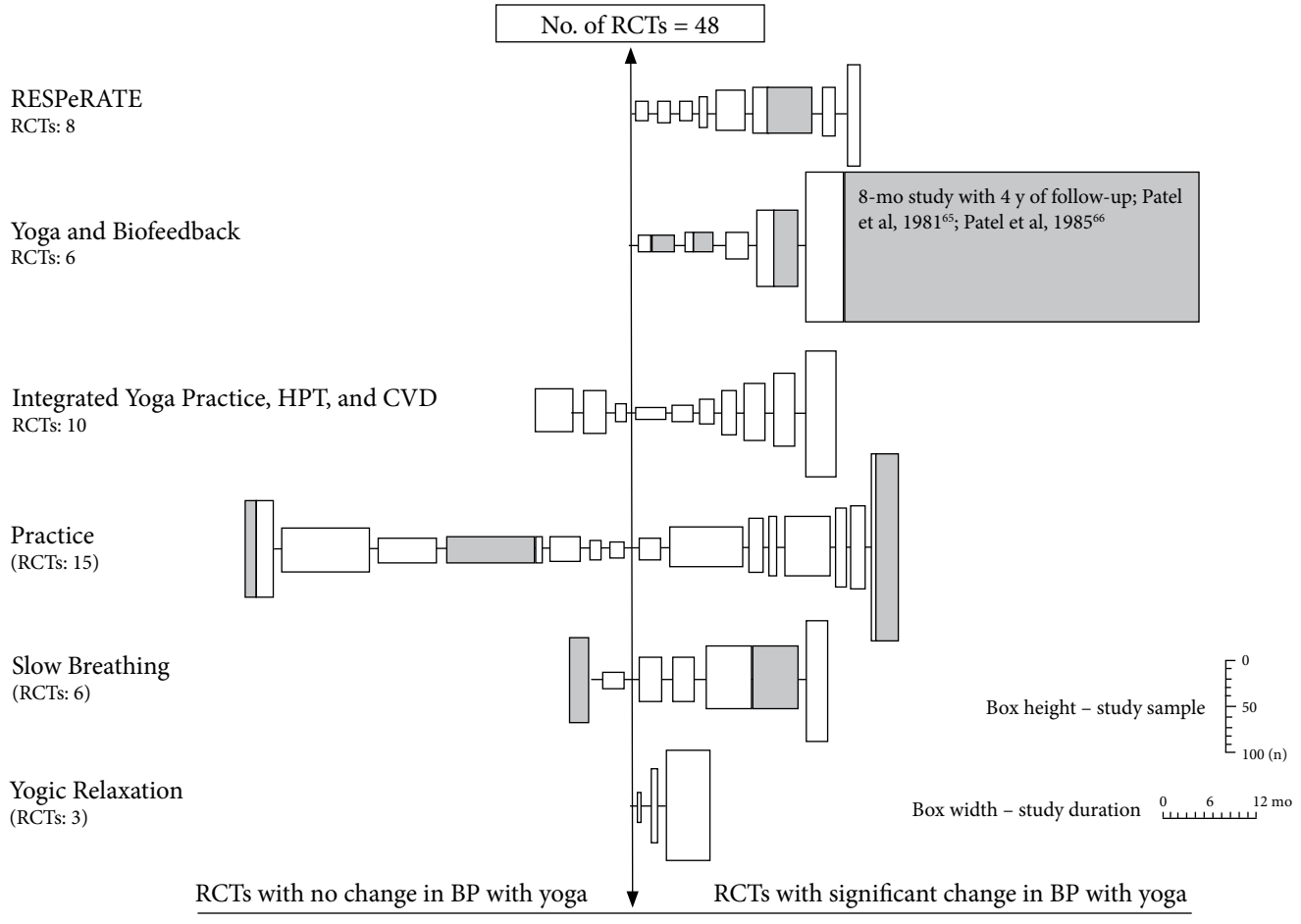

Table 1. Summary of Cohort Studies Reporting Changes in BP With Yogic Relaxation Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Datey et al, 1969[26]	Cohort, 3 wk	Hypertensive (n = 47); untreated group (n = 10); group on antihypertensive medication (n = 22); group poorly controlled with drugs (n = 15)	Shavasana	Preintervention vs postintervention	↓ 27 mm Hg in mean BP ($P < .05$) for untreated group and ↓ 10 mm Hg in mean BP ($P < .05$) for group with hypertension poorly controlled with medication compared with preintervention	↓ of 32% ($P < .05$) for group with hypertension controlled with medication and 29% ↓ for group with hypertension poorly controlled with medication
Sundar et al, 1984[67]	Cohort, 6 mo with 3 y of follow-up	Hypertensive (n = 25); untreated hypertensive group (n = 20); medically treated hypertensive group (n = 5)	Shavasana 2 ×/d	Preintervention vs postintervention	↓ of 14/11.6 mmHg in SBP/DBP ($P < .001/P < .001$) for untreated hypertensive group and ↓ of 31.2/18.8 mm Hg ($P < .001/P < .001$) for treated hypertensive group compared with preintervention	BP was maintained in regular practitioners in follow-up period despite 33.3%-80% reduction in antihypertensive drug use with mean reduction of 47.6%
Madanmohan et al, 2002[68]	Cohort, 7 d	Healthy normotensive group (n = 10)	Shavasana	Preintervention vs postintervention	No change in resting BP	↓ of 4.4 BPM in resting HR ($P < .05$)
Sharma et al, 2007[69]	Cohort, 4 wk	Healthy normotensive group (n = 60)	Shavasana	Preintervention vs postintervention	↓ of 6.5/3.02 mm Hg in SBP/DBP ($P < .001/P < .001$) after 10 min of practice; greater reduction after 4 wk ($P < .001/P < .001$)	↓ of 3.1 BPM in pulse rate ($P < .001$)

Abbreviations: SBP = systolic blood pressure; DBP = diastolic blood pressure; BPM = beats per minute; HR = heart rate.

reductions in BP in untreated hypertensive patients as well as in those poorly controlled on medication (Table 1).[26] A similar reduction in BP was reported in a 6-month study of 25 hypertensive patients practicing yogic relaxation, with BP reductions being maintained after 3 years in those individuals who continued with regular practice despite reduced use of antihypertensive medication.[67] Yogic relaxation practices were reported to have both acute and long-term effects, with significant decreases in resting BP and heart rate (HR) reported in healthy young participants after a single 10-minute session of shavasana and with progressive BP reductions reported after 8 weeks of practice.[69] In contrast, a small study involving 10 healthy participants practicing shavasana for 7 days found no change in BP despite a significant drop in HR.[68]

Yogic Relaxation Controlled Trials

Table 2 shows reductions in BP with yogic relaxation that were reported in an adolescent population after 6 weeks of shavasana practice[70] and in healthy participants after 3 months of practice of either shavasana or Transcendental Meditation[71] as well as 3 weeks of practice of either hatha yoga or progressive muscle relaxation.[72] Yoga relaxation practices have also been shown to reduce BP significantly in RCTs of 8 days involving hypertensive patients[73] and of 8 months in women with monaural irregularities,[74] with BP remaining unchanged in control groups. A 6-month study suggests that relaxation practices may be particularly important in reducing BP, with the finding that normotensive elderly participants who practiced silver yoga, either with or without relaxation, had similar improvements in physical fitness compared with waiting-list controls, but that only the relaxation group experienced significant reductions in SBP.[75] Similarly, a 4-week NRCT reported significant falls in BP in hypertensive patients when relaxation practices were conjoined with drug therapy (n = 50), although BP in healthy participants practicing relaxation (n = 10) remained unchanged.[76]

Slow Breathing Cohort Studies

Several authors have reported significant reductions in resting BP in healthy participants after 4 weeks of practicing alternate nostril breathing (Table 3).[77,78] An 8-week study also reported similar significant reductions in resting BP after a single 15-minute session of alternate nostril breathing (ANB) as well as progressive BP reductions with longer practice.[79] Additionally, a recent 12-week study reported significant reductions in BP in normotensive participants studying *mukh bhastrika pranamyama*.[80]

Not all studies on yoga breathing reported reductions in BP. One small study involving 6 healthy participants reported no change in BP after 6 months, despite reductions in pulse rate, fasting blood glucose, and blood lipids.[81] Similarly, a 3-month study of normotensive participants (n = 6) and participants with chronic obstructive pulmonary disease (COPD) (n = 11) reported unchanged BP, together with an increase in low frequency (LF) and LF/high-frequency (HF) values, indicating sympathetic activation after 3 months of ANB.[82]

Table 2. Summary of Controlled Trials Reporting Changes in BP With Yogic Relaxation Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Bagga et al, 1983[71]	NRCT, 12 wk, 20 min/d	Healthy normotensive (n = 18)	TM (n = 6); shavasana (n = 6); controls: relaxed, closed-eye sitting (n = 6)	Preintervention vs postintervention	↓ of 8.94/4.6 mm Hg in SBP/DBP ($P < .01/P < .05$) after TM, ↓ 7.27/2.4 mm Hg ($P < .05/P < .05$) after shavasana compared with preintervention; no change in controls	↓ of 9.97 BPM in HR ($P < .01$) and of 7.9 BPM ($P < .05$) after TM and shavasana, respectively, compared with preintervention
Chaudhary et al, 1988[76]	NRCT, 4 wk	Hypertensive and normotensive (n = 60); hypertensive group (n = 50); healthy group (n = 10)	All experimental groups: yogic relaxation and pharmacological treatment (n = 50); controls: relaxation (n = 10)	Preintervention vs postintervention	↓ of in BP 25.18/ 25.16 mm Hg in relaxation group compared with preintervention (*P* values not provided); no change in controls	
Cusumano et al, 1993[72]	RCT, 3 wk, 3 sessions/wk of 80 min each	Healthy female normotensive (n = 95)	YP group (n = 45); PMR group (n = 45)	Preintervention vs postintervention and comparisons between the groups	↓ of 3.49 mm Hg mean BP in yoga group and ↓ of 2.17 mm Hg in mean BP in PMR group compared with preintervention (*P* values not provided); no significant differences between the interventions	↓ of 3.22 in BPM and 4.13 in BPM in HR in YP and PMR groups, respectively (*P* values not provided)
Broota et al, 1995[73]	RCT, 8 d	Hypertensive (n = 40)	Shavasana (n = 10); baroota relaxation group (n = 10); PMR group (n = 10); controls: no intervention (n = 10)	Preintervention vs postintervention and comparisons between the groups	Significant reduction in BP ($P < .01$) with all relaxation therapies compared with preintervention; no change in controls	Shavasana was most effective and prominent in reduction, followed by baroota and PMR
Madanmohan et al, 2004[70]	NRCT, 6 wk	Healthy normotensive adolescents (n = 43)	Shavasana group (n = 26); controls: no intervention (n = 17)	Preintervention vs postintervention	↓ of 5/4 mm Hg in SBP/DBP ($P < .05/P < .03$) in shavasana group compared with preintervention; no change in controls	↓ of 5 BPM in HR ($P < .01$)
Chen et al, 2008[75]	NRCT, 24 wk	Elderly seniors > 60 y (n = 176)	Silver yoga group with guided relaxation: 70 min each session for 3 d/wk (n = 53); silver yoga group without guided relaxation: 55 min/session for 3 ×/wk (n = 53); waitlist controls (n = 66)	Preintervention vs postintervention	Significant reduction in SBP ($P < .05$) in yoga group with guided relaxation compared with preintervention; no change in BP in yoga group without guided relaxation; no change in waitlist controls	All physical fitness indicators (flexibility and motion) improved similarly in both experimental groups ($P < .05$)
Monika et al, 2012[74]	RCT, 6 mo	Females with symptoms of menstrual irregularity (n = 150)	Yoga nidra group: 40 min/session for 5 d/wk (n = 75); controls: regular medication (n = 75)	Preintervention vs postintervention	↓ of 2.98/4.22 mm Hg in SBP/DBP ($P < .01/P < .0005$) after yoga nidra compared with preintervention; nonsignificant change in controls with medication	↓ of 3.93BPM in HR ($P < .01$) and improvement in symptoms of menstrual irregularities after yoga nidra compared with preintervention; positive improvement in LF/HF ratio after yoga nidra

Abbreviations: TM = Transcendental Meditation; YP = yoga; PMR = progressive muscle relaxation; LF = low frequency; HF = high frequency.

Table 3. Summary of Cohort Studies Reporting Changes in BP With Slow Breathing Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Udupa et al, 1975[81]	Cohort, 6 mo	Normotensive (n = 6)	Yoga breathing, ujjayi and bhastrika	Preintervention vs postintervention	No change in resting BP	↑ of 2 kg in body weight ; ↓ in fasting glucose, total serum lipid, and serum protein (*P* values not provided)
Bhargava et al, 1988[78]	Cohort, 4 wk	Normotensive (n = 10)	ANB for 30 min/session	Preintervention vs postintervention	↓ of 8.8/5.16 mm Hg in resting SBP/DBP ($P < .01/P < .05$) compared with preintervention	No change in resting HR
Srivastava et al, 2005[79]	Cohort, 8 wk	Normotensive (n = 40)	ANB for 15 min/session	Preintervention vs postintervention	↓ of 6.4 mm Hg and 3.6 mm Hg ($P < .0001$ and $P < .01$) in SBP in males in females compared with preintervention	↓ of 12.55 and 11.7 BPM in HR males and females, ($P < .001$ and $P < .001$), respectively, after 8 wk
Upadhyay et al, 2008[77]	Cohort, 4 wk	Normotensive (n = 36)	ANB for 15 min/session	Preintervention vs postintervention	↓ of 4.16 mm Hg in DBP ($P < .001$) compared with preintervention	↓ of 3 BPM in pulse rate ($P < .001$) and improvement in respiratory variables ($P < .001$)
Veerabhadrappa et al, 2011[80]	Cohort, 3 mo	Normotensive males (n = 50)	Mukh bhastrika	Preintervention vs postintervention	↓ of 4.72 mm Hg in supine mean BP ($P < .001$), and ↓ of 2.32 mm Hg in standing mean BP ($P < .01$) compared with preintervention	↓ of 13.4 BPM ($P < .001$) in HR
Jaju et al, 2011[82]	Cohort, 3 mo	Normotensive with COPD (n = 11); healthy normotensive (n = 6)	ANB with extended retention (6:6:6) for 30 min in each session for 5 d/wk	Preintervention vs postintervention	No change in BP in COPD participants: ↑ in DBP in normotensive controls ($P < .01$)	Nonsignificant ↑ in LF and LF/HF values in both groups, indicating sympathetic activation

Abbreviations: COPD = chronic obstructive pulmonary disease; ANB = alternate nostril breathing; BPM = beats per minute.

Slow Breathing Controlled Trials

The above cohort studies are supported by a series of controlled clinical studies (Table 4). Two separate RCTs with durations of 3 months reported reductions in SBP after regular breath-awareness meditation practice in adolescents with borderline HPT.[83,84] Reductions in SBP were also observed with slow breathing in a placebo-controlled trial of hypertensive patients who were randomly assigned either to listen to music, read a book, or perform breathing that was synchronized to slow musical rhythms at 4.6 breaths/minute (BPM).[85] Three months of either slow breathing at 6 BPM or fast breathing at 60 BPM was also found to reduce BP in another RCT involving hypertensive patients, with BP reductions being more prominent after slow breathing.[86]

Additionally, 3 NRCTs, 1 lasing 6 weeks and 2 lasting 8 weeks, reported a reduction in BP in normotensive participants.[87-89] BP was reported to be reduced after a single session of either right nostril breathing (RNB) or left nostril breathing (LNB), with a more pronounced drop reported after 8 weeks of practice.[88] Significant falls in BP were also reported with ANB after 8 weeks when compared with sun salutation[89] and after 6 weeks when compared with no intervention.[87] A more recent 3-month NRCT reported significant reductions in BP with yogic breathing maneuvers comprising *ujjayi, bhastrika*, chanting, and breath-focused meditation practices.[90] Furthermore, a small study of 30 participants reported significant reductions in DBP after 3 weeks of slow breathing practice (*savitri pranayama*) and a nonsignificant rise in DBP, with a significant rise in HR with fast-paced *bhastrika* breathing.[91] However, 2 RCTs of 3 months reported no change in BP in normotensive adolescents practicing various different types of slow pranayamic breathing[92] and in diabetic participants practicing slow diaphragmatic breathing, despite significant improvement in CVD risk factors.[93]

Integrated Yoga Practice Cohort Studies

Significant BP and HR reductions have been consistently observed with integrated yoga practices (Table 5). Cohort studies involving healthy volunteers performing yoga postures and breathing practices have reported reductions in BP and HR after 2 weeks,[94] 2 months,[95] 3 months,[96] and 6 months.[97] Significant reductions in BP with breathing and postural practices were also observed in 13 hypertensive participants after 4 weeks[98] and in 10 hypertensive participants and 17 hypertensive participants with CAD after 5 weeks but not in participants with CAD alone.[99] In contrast

Table 4. Summary of Controlled Trials Reporting Changes in BP With Slow Breathing Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Udupa et al, 2003[92]	RCT, 3 mo	Normotensive adolescents (n = 24)	Pranayama group: ANB, mukh bhastrika, pranav, savitri (n = 12); controls: no intervention (n = 12)	Preintervention vs postintervention	No change in BP in either group	↓ of 6.16 BPM in HR ($P < .01$) in pranayama group
Madanmohan et al, 2005[91]	NRCT, 3 wk	Normotensive (n = 30)	Slow breathing group with breath hold: savitri pranayama, 2:1:2:1 (n = 15); fast breathing group: bhastrika (n = 15)	Preintervention vs postintervention	↓ of 2.93 mm Hg in DBP ($P < .05$) with slow breathing compared with preintervention; nonsignificant increase in DBP with fast breathing, compared with preintervention	Nonsignificant decrease in HR with slow breathing; ↑ of 6.44 BPM in HR ($P < .05$) with fast breathing
Jain et al, 2005[88]	NRCT, 8 wk	Normotensive (n = 40)	RNB group (n = 20) and LNB group (n = 20): each with 15-min sessions/d for 8 wk	Preintervention vs postintervention	↓ of 6/5 mm Hg in SBP/DBP ($P < .001/P < .05$) in males and of 5 mm Hg in DBP ($P < .01$) in females with RNB, compared with preintervention; ↓ of 9/7 mm Hg in SBP/DBP ($P < .001/P < .01$) in males and 8/5 mm Hg ($P < .01/P < .05$) in females with LNB compared with preintervention	↓ of 12 BPM and 3 BPM in HR, ($P < .01$) and ($P < .05$) in males and females, respectively, after RNB; ↓ of 16 BPM and 13 BPM in HR ($P < .001$) and ($P < .05$) in males and females, respectively, after LNB
Barnes et al, 2008[83]	RCT, 3 mo	Borderline hypertensive adolescents (n = 66)	BAM group: slow, deep, relaxed, and focused diaphragmatic breathing (n = 20); HEC group: education on BP, weight reduction, and diet—salt and fat reduction (n = 46)	Preintervention vs postintervention	↓ of 4.7 mm Hg in SBP ($P < .05$) during school and 4.8 mm Hg ($P < .01$) during night in BAM group compared with preintervention; no statistically significant change in HEC	↓ of 6.7BPM in HR ($P < .02$) during school and 2.2 BPM ($P < .03$) at night with BAM
Mourya et al, 2009[86]	RCT, 3 mo	Hypertensive (n = 60)	Slow breathing group: 5-6 BPM, occluding either nostril alternatively (n = 20); fast breathing group: short and quick 60 BPM for 1 min followed by 3-min pause (n = 20); controls: no intervention (n = 20)	Preintervention vs postintervention	Significant fall in SBP/DBP with slow ($P < .0001/P < .0001$) and fast breathing ($P < .004/P < .003$)	
Modesti et al, 2010[85]	RCT, placebo-controlled, 6 mo, with 6 mo of follow-up	Hypertensive (n = 86)	Slow breathing group: synchronized with music up to 4-6 BPM as per Buteyko method, 10 min and 20 min abdominal breathing with 1:2 inspiration and expiration ratio (n = 29); slow music to relax group (n = 26); controls: reading book or magazine (n = 31)	Preintervention vs postintervention and comparison between groups	↓ of 7.4 mm Hg in office SBP ($P < .05$); ↓ of 7.5 mm Hg in 24-h ambulatory SBP ($P < .0001$) at follow-up compared with preintervention; no change for music relaxation and book reading; reduction in slow breathing group ($P < .001$) compared with slow music and book reading	No change in drug score for any group
Fareedabanu et al, 2010[89]	NRCT, 8 wk	Normotensive (n = 40)	ANB group: 20 min/d, (n = 20); sun salutation group: 10 cycles in 20 min (n = 20)	Preintervention vs postintervention	↓ of 5.15/1.05 mm Hg in resting SBP/DBP ($P < .05/P < .05$) with ANB compared with preintervention; nonsignificant change with sun salutation	↓ of 4.73 BPM in HR ($P < .05$) with ANB and nonsignificant change with sun salutation

Table 4. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Singh et al, 2011[87]	NRCT, 6 wk	Normotensive (n = 30)	ABN group: 30-min/d (n = 30); controls: no intervention (n = 15)	Preintervention vs postintervention	↓ of 4.94 mm Hg in SBP ($P < .05$), with ANB compared with preintervention; no change in controls	↓ of 10.1 BPM in HR ($P < .01$) with ANB
Malik et al, 2011[90]	NRCT, 3 mo	Normotensive (n = 150)	Yoga breathing group: ujjayi, bhastrika, humsa chanting, and shavasana meditation (n = 100); controls: no intervention (n = 50)	Preintervention vs postintervention	↓ of 8.6 mm Hg in SBP ($P < .0001$) after yoga breathing compared with preintervention; no change in controls	↓ of 11.4 BPM in HR ($P < .0001$) after yoga breathing; ↓ of 56 L/min in PEFR ($P < .0001$ for experimental group
Gregoski et al, 2011[84]	RCT, 3 mo	Borderline hypertensive adolescents (n = 166)	BAM group: slow, deep, relaxed, and focused diaphragmatic breathing (n = 53); LST group (n = 69); HEC controls: education on BP, weight reduction, and diet—salt and fat reduction (n = 44)	Comparison between groups	↓ of 3.1 mm Hg in SBP with BAM ($P < .01$) compared with LST and ($P < .02$), compared with HEC; ↓ of 2 mm Hg in DBP with BAM ($P < .03$) compared with LST and 1.7 mm Hg (nonsignificant) compared with HEC	Reduction of 3.2 BPM in HR with BAM ($P < .01$) compared with LST
Hegde et al, 2012[93]	RCT, 3 mo with follow-up	Type 2 diabetes (n = 123)	DB group: slow, deep, mindful, relaxed breathing, either in supine or sitting position for 20-min session 2 ×/d (n = 60); controls: standard care including information about diet and exercise (n = 63)	Preintervention vs postintervention follow-up and comparison between groups	Nonsignificant change in BP with DB at follow-up compared with preintervention; no significant difference between the groups	Improvement in glycemic index—fasting and postprandial ($P < .001$ and $P < .007$, respectively) at follow-up with DB compared with preintervention; improvement in BMI ($P < .003$) and WHR ($P < .001$) with DB compared with control at follow-up

Abbreviations: ANB = alternate nostril breathing; RNB = right nostril breathing; LNB = left nostril breathing; BAM = breath awareness meditation; HEC = health education control; BPM = breaths or beats per minute; LST = lifestyle training; DB = diaphragmatic breathing; PEFR = peak expiratory flow rate; WHR = waist-hip ratio.

to those findings, 4 studies involving normotensive participants reported no change in BP.[100-103] Of these, 2 small studies of 8 people reported no change in BP after 2 weeks of practicing a single yoga posture (shoulder stand posture)[100] and 4 weeks of practicing a defined sequence of postures, breathing, and chanting (*shanti kriya*).[101] Similarly, no significant change in BP was reported in a 6-week study of 64 medical students undertaking a single weekly yoga session and regular home practice[102] or in an 11-week study of 17 middle and elderly yoga practitioners undertaking intense yoga training.[103] Additionally, BP remained unchanged despite improvements in heart rate variability (HRV) and mood states in a further 4-week study of laughter yoga involving 6 participants awaiting organ transplants.[104]

Integrated Yoga Practice Controlled Studies

Controlled trials of integrated yoga interventions were consistent with the above cohort studies (Table 6). Differential effects on BP with different yoga practices were observed in a 6-week study of healthy participants that found significant falls in DBP with *ashtanga* yoga compared with a lesser, nonsignificant reduction in BP with hatha yoga.[105] Two controlled trials involving healthy normotensive people reported larger reductions in BP after 10 weeks[106] and 6 weeks[107] compared with controls receiving no intervention. A recent controlled trial also reported significant reductions in BP with sahaj yoga in hypertensive participants with or without type 2 diabetes (n = 67) compared with participants with standard medical treatment (n = 62), with the reductions being more prominent among the diabetic participants.[108] A further 3-month RCT of 30 healthy soldiers reported reductions in BP for those adhering to a hatha yogic lifestyle, including dietary measures compared with no change in BP for those undertaking only aerobic exercise.[31] Reductions in BP with integrated yoga practices were also reported in a 6-month RCT of depressive participants practicing kundalini yoga, compared with participants taking antidepressant medication.[109] A 2-month RCT of gentle *Iyengar* yoga in postmenopausal women with restless leg syndrome also found reductions in BP compared with a control group receiving instruction on general awareness through personal interaction and visual aids.[110]

Similarly, BP reductions were reported in participants with rheumatoid arthritis after 40 days of yoga compared

Table 5. Summary of Cohort Studies Reporting Changes in BP With Integrated Yoga Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Lakshmikantha et al, 1979[99]	Cohort, 5 wk	Hypertensive and CAD patients (n = 44); hypertensive group (n = 10); CAD + hypertensive group (n = 17); CAD group (n = 17)	Yoga, postural and relaxation	Preintervention vs postintervention	↓ of 9.7/8.8 mm Hg in SBP/DBP ($P < .05/P < .01$) in hypertensive group and ↓ of 12.9/8.47 mm Hg ($P < .05/P < .01$) in hypertensive + CAD group postyoga and relaxation compared with preintervention; no change in CAD patients	
Anantharaman et al, 1984[96]	Cohort, 3 mo	Normotensive (n = 17)	Integrated yoga: postural practices coordinated with pranayamic breathing movement	Preintervention vs postintervention	↓ of 3.2/4.4 mm Hg in SBP/DBP ($P < .05/P < .05$) with yoga intervention compared with preintervention	↓ of 5.93 BPM in pulse rate ($P < .05$)
Satyanarayana et al, 1992[101]	Cohort, 30 d	Normotensive (n = 8)	Shanti kriya: yogic postures incorporated with breathing, meditation, chanting, and relaxation	Preintervention vs postintervention	No significant change in BP	No change in pulse rate
Konar et al, 2000[100]	Cohort, 2 wk	Normotensive (n = 8)	Sarvangasana (shoulder stand posture)	Preintervention vs postintervention	No significant change in BP	↓ in resting HR ($P < .02$)
Madanmohan et al, 2004[95]	Cohort, 2 mo	Normotensive (n = 21)	Yoga postures and yoga breathing	Preintervention vs postintervention	↓ of 2.9/6.19 mm Hg in resting SBP/DBP ($P < .01/P < .001$) with yoga intervention compared with preintervention; ↓ of 5.95 mm Hg in MAP ($P < .001$)	↓ of 5.62 BPM in resting HR ($P < .01$)
Vijayalakshmi et al, 2004[98]	Cohort, 4 wk	Hypertensive (n = 13)	Yoga postures and yoga breathing	Preintervention vs postintervention	↓ of 21/11.93 mm Hg in SBP/DBP ($P < .001/P < .001$) and ↓ of 12.46 mm Hg in MAP ($P < .001$) after yoga intervention compared with preintervention	↓ of 10.15 BPM in HR ($P < .0001$) after yoga intervention
Ramos-Jiménez et al, 2009[103]	Cohort, 11 wk	Normotensive female yoga practitioners practicing yogic exercises of low aerobic intensity for > 3 y (n = 17)	Intensive hatha yoga program with dynamic stretching, postures, breathing, and meditation, 90 min/session 5 d/wk	Preintervention vs postintervention	No change in BP	Improvement in $VO2_{max}$ ($P < .05$)
Herur et al, 2010[97]	Cohort, 6 mo	Normotensive (n = 50)	Yoga: stretching, prayers, asana pranayama, meditation, relaxation	Preintervention vs postintervention	↓ of 8/6 mm Hg in SBP/DBP ($P < .001/P < .001$) with yoga postintervention compared with preintervention	↓ of 6.5 BPM in HR ($P < .001$); improvement in general health questionnaire ($P < .001$) with yoga postintervention
Ankad et al, 2011[94]	Cohort, 2 wk	Normotensive (n = 50)	Yoga: pranayama and meditation	Preintervention vs postintervention	↓ of 3.8/3.08 mm Hg in SBP/DBP ($P < .001/ P < .001$) postintervention compared with preintervention	↓ of 3.68 BPM in pulse rate ($P < .001$)
Dolgoff-Kaspar et al, 2012[104]	Cohort, 4 wk	Patients awaiting organ transplant (n = 6)	Laughter yoga: 7 sessions of 20 min with breathing and stretching and laughter exercise with rhythmic clapping and guided meditation	Preintervention vs postintervention	No change in BP with yoga postintervention	Improvement in time domain analysis of HRV; improvement on the scores of profile and mood states

Table 5. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Parshad et al, 2012[102]	Cohort, 6 wk	Normotensive (n = 64)	Yoga: asanas, pranayama, and meditation 1 ×/wk for 60 min and regular 10-min practice of mediation at home	Preintervention vs postintervention	No change in BP postyoga intervention compared with preintervention	↑ in HR ($P < .05$), CO ($P < .001$), SV ($P < .01$), and CO ($P < .01$) and ↓ in IBI ($P < .01$) with yoga postintervention compared with preintervention

Abbreviations: CAD = coronary artery disease; MAP = mean arterial pressure; BPM = beats per minute; $VO2_{max}$ = maximal oxygen uptake; HRV = heart rate variability; CO = cardiac output; SV = stroke volume; IBI = interbeat interval.

with waitlist controls[111] and in osteoarthritis participants after 3 months of follow-up preceded by 15 days of yoga compared with therapeutic exercise.[112] Additionally, a 10-week RCT reported reductions in BP in an elderly group practicing yoga in weekly sessions with home practice compared with a control group engaged in physical entertainment, with more prominent reductions observed in a subgroup attending class and regularly practicing at home.[113]

Controlled studies in hypertensive individuals suggest that reductions in BP with yoga practice may be augmented by other lifestyle modification, such as physical activity and dietary modifications. A recent 9-month NRCT reported improvement in HRV and falls in BP in hypertensive and normotensive people practicing yoga, with reductions becoming statistically significant only in those practicing yoga together with physical exercise.[114] Similarly, an 8-week RCT that examined the effects of yoga, brisk walking, and salt reduction in hypertensive participants found that significant reductions in BP occurred with yoga as well as with brisk walking and salt reduction compared with controls receiving no intervention.[115]

A number of studies have compared yoga groups to no-intervention or active-intervention controls, and 1 study reported reductions in BP with a yoga intervention similar to a head-tilt active control group.[116] Not all controlled trials reported BP reductions. No change in BP with yoga was reported in normotensive participants after 24 months of yogic breathing and relaxation[117] or after 8 weeks of Iyengar yogic techniques using various props[118] compared with control participants maintaining their regular lifestyles.

Seven RCTs reported no change in BP in yoga groups compared with no-intervention or active controls, despite other significant benefits. A nonsignificant reduction in BP was reported in 3 controlled trials in sedentary populations: (1) after 6 weeks of gentle yoga in sedentary, normotensive, elderly participants, despite significant reductions in HR[119]; (2) after 8 weeks of *Bikram* yoga in sedentary, normotensive young adults, despite significant improvement in body flexibility[120]; and (3) after 8 months of ashtanga yoga in sedentary, normotensive, premenopausal women, despite improvements in muscle strength.[121] Similarly, a nonsignificant change in BP, despite significant reductions in HR, was reported in a 10-week controlled trial of yoga and relaxation for people with mild to moderate stress.[122] Nonsignificant changes in BP, despite significant improvements in psychological stress, were also reported in a 12-week study of integrated yoga in medical students under examination stress[123] and in a 16-week study of kundalini yoga in a population under mild stress.[124] A further RCT involving mild hypertensive participants reported no reduction in BP after 1 year of yoga relaxation or nonspecific counseling.[125]

Integrated Yoga Practice for Cardiac Risk Factors

A significant body of laboratory and clinical evidence suggests that yoga balances autonomic responses and improves BP and other CVD variables in both healthy and hypertensive participants, with reductions in body weight, body fat mass, and BMI,[33,34,126-140] hypercholesterolemia,[33,34,41,127,129,137-139,141-145] and hyperglycaemia.[34,41,129,133,135,137-139,141,145-147]

Cohort Studies on Integrated Yoga Practice for Cardiac Risk Factors

Reductions in BP, HR, and body weight were reported in a study of 30 healthy sports teachers after 3 months of residential yoga training,[126] and reductions in BP and body fat were reported in participants over age 65 after 4 weeks of silver yoga practice involving gentle yoga movements and postures together with rhythmic breathing and relaxation (Table 7).[130] More recently, a reduction in BP was reported in 2 studies, each with 50 healthy volunteers, 1 after 6 weeks with significant improvement in body fat percentage and weight[128] and 1 after 6 months with significant reduction in HR and body weight.[131]

In addition to improving BP and body weight, integrated yoga practices were found to improve blood lipids in a study of normotensive and hypertensive participants[127] and improvements in BP and lipids along with glycemic index were reported in studies of healthy normotensive participants[41,129] and in a population with metabolic abnormalities.[34] Improvements in BP and better glycemic control were also reported in diabetic individuals after 40 days of yoga practice.[146]

Cohort studies have also reported reductions in use of antihypertensive medications together with improvements in BP, lipid profile, and glycemic index after 3 months[141] and

Table 6. Summary of Controlled Studies Reporting Changes in BP With Integrated Yoga Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Haber, 1983[113]	RCT, 10 wk	Healthy elderly population (white and black) from 2 community centers (n = 106)	Yoga group: gentle yoga 2 ×/wk with in-class and in-home practice (n = 63); control group: either film series or art activity (n = 43)	Preintervention vs postintervention and comparisons between the groups	↓ of 12/7 mm Hg in SBP/DBP in the community with white elders practicing yoga on regular basis, with higher income and educational levels and reported good health on self-rated scale; ↓ of 7/4 mm Hg in the community with black elders practicing yoga irregularly, with lower educational and income levels and reported fair health on self-rated scale (*P* values not provided); significant reduction in BP of white elders compared with control ($P < .05$); nonsignificant difference in black elders compared with controls	Improved psychological well-being in white elderly community compared with black elderly community ($P < .05$)
Devi et al, 1986[109]	RCT, 6 mo	Depressive (n = 80)	Kundalini yoga group: asana, pranayama, and concentration on chakras, 60 min/d (n = 40); group using usual antidepressant drugs (n = 40)	Preintervention vs postintervention	↓ of 8/8 mm Hg in SBP/DBP ($P < .01/P < .001$) with yoga, compared with preintervention; ↓ of 11/9 mm Hg in SBP/DBP ($P < .001/P < .001$) with drug therapy compared with preintervention	↓ in pulse 13 BPM ($P < .001$) and 14 BPM ($P < .001$) with yoga and drugs, respectively
Van Montfrans et al, 1990[125]	RCT, placebo control, 8 wk, with 12 mo of follow-up	Hypertensive (n = 35)	Yoga group: muscle relaxation, yoga exercise, and stress management (n = 18); control group: sit and relax 2 ×/d (n = 17)	Preintervention vs postintervention at the end of follow-up period	No change in BP in both groups	
Raju et al, 1994[117]	NRCT, 24 mo	Normotensive (n = 28)	Yoga group: breathing and relaxation with physical workouts (n = 14); control group: physical workouts (n = 14)	Preintervention vs postintervention	No significant change in resting BP in both groups compared with preintervention	No change in resting HR
Bowman et al, 1997[119]	RCT, 6 wk	Sedentary normotensive elderly >62 y (n = 26)	Yoga group: stretching postures and breathing with 20 min relaxation (n = 12); aerobic exercise group: 40-min session of warm-up, workload to increase HR, and warm-down training (n = 14)	Preintervention vs postintervention	No significant change in BP in either group; reduction in BP prominent in aerobic group compared with yoga group	↓ of 8 BPM in HR ($P < .05$) in yoga group compared with preintervention; no significant change in HR in aerobic group
Selvamurty et al, 1998[116]	NRCT, 3 wk	Hypertensive (n = 30)	Yoga group: specific yoga posture of head up or down tilt for 30 min/d (n = 20); control group: 70° head tilt for 30 min/d (n = 10)	Preintervention vs postintervention	↓ of 29/17 mm Hg in SBP/DBP ($P < .001/P < .001$) in yoga group and ↓ of 21/21 mm Hg in tilt group ($P < .001/P < .001$) postintervention compared with preintervention	↓ of 7 BPM in HR ($P < .01$) in yoga group and 9 BPM in tilt group ($P < .05$) compared with their respective preintervention values; progressive improvement in baroreflex sensitivity in both groups

Table 6. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Ray et al, 2001[106]	RCT crossover trial, 10 mo	Normotensive (n = 54)	Comprehensive yoga intervention group: asanas, pranayama, mudra, and cleansing practices (n = 28); waitlist control group: continued similar exercises postintervention for 5 mo (n = 26)	Preintervention vs postintervention	↓of 10.17 mm Hg and 11.2 mm Hg in SBP ($P < .001$) for males and females, respectively, of yoga group compared with preintervention; ↓ of 8.75 mm Hg and 8.4 mm Hg in SBP ($P < .001$ and $P < .05$) in males and females, respectively, of waitlist control compared with preintervention; nonsignificant change in DBP in both groups	Significant reduction in HR in both groups
Harinath et al, 2004[31]	RCT, 3 mo	Normotensive (n = 30)	Integrated yoga group: asanas, pranayama, meditation in 60-min sessions 2 ×/d (n = 15); aerobic exercise group: body flexibility, slow running, games in 60-min sessions 2 ×/d (n = 15)	Preintervention vs postintervention	↓ of 9.2/9.6 mm Hg in SPP/DBP ($P < .001/P < .001$) in yoga group compared with preintervention; no change in BP of aerobic group	No significant change in HR
Cowen et al, 2005[105]	NRCT, 6 wk	Normotensive (n = 26)	Ashtanga yoga group: asanas, ujjayi breathing, and warm-up with sun salutation (n = 15); hatha yoga group: asanas, relaxation, breathing, and warm-up of sun salutation (n = 11); yoga sequences were performed for 75 min 2 ×/wk	Preintervention vs postintervention	Significant reduction in DBP with both yoga styles but prominent reductions with ashtanga yoga	Improvement in upper-body-and-trunk dynamic muscular strength with yoga training
Granath et al, 2006[124]	RCT, 16 wk	Normotensive with mild stress (n = 33)	Kundalini yoga group: balancing body movements, breathing, meditation, and diet awareness (n = 16); CBT group: psychoeducation management techniques for stress, anger, and mindful relaxation (n = 17)	Preintervention vs postintervention	Nonsignificant change in BP in both groups	Significant reduction in HR ($P < .07$) in yoga group compared with preintervention; improvement in psychological markers of stress in both groups, compared with their respective preintervention values
Smith et al, 2007[122]	RCT, 10 wk, with 6 wk follow-up	Normotensive with mild stress (n = 131)	Yoga intervention group: asana, pranayama, relaxation, and meditation (n = 68); PMR group: audio tape with music in 10- to 15-min sessions/wk (n = 63)	Preintervention vs postintervention	No change in BP with either intervention	Significant improvement in stress and anxiety scores in both groups, with magnitudes being prominent with yoga; improvement was maintained after follow-up periods of 6 wk

Table 6. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Madanmohan et al, 2008[107]	NRCT, 6 wk	Normotensive (n = 46)	Yoga intervention group: asana, pranayama, and relaxation (n = 23); no intervention control (n = 23)	Preintervention vs postintervention	↓ of 12 mm Hg and 7 mm Hg in DBP ($P < .02/P < .03$) in males and females, respectively, with yoga postintervention compared with preintervention; no change in controls	No change in HR; improvement in muscle strength and endurance ($P < .05$)
Niranjan et al, 2009[114]	NRCT, 9 mo	Hypertensive and normotensive (n = 78)	Yoga group: postures, breathing, and relaxation (n = 16); exercise group: warming, cycling/treadmill (n = 16); yoga + exercise group (n = 15); normotensive control group (n = 31)	Preintervention vs postintervention and comparison between groups	↓ of 7.57/6.12 mm Hg in SBP/DBP ($P < .05/P < .05$) in exercise group and ↓ of 7.3/6.94 mm Hg ($P < .05/P < .05$) in exercise group and yoga + exercise group postintervention compared with preintervention; nonsignificant drop in yoga group	Improved HRV in exercise group ($P < .001$) and yoga + exercise ($P < .001$) group; nonsignificant change in yoga group compared with preintervention
Saptharishi et al, 2009[115]	RCT, 8 wk	Hypertensive (n = 113)	Yoga group: 30-45 min/d for 5 d (n = 27); brisk walk group: 50-60 min, 4 d/wk (n = 28); salt reduction group: half previous intake (n = 28); no-intervention control group (n = 30)	Preintervention vs postintervention and comparison between groups	↓ of 2/2.6 mm Hg in SBP/DBP with yoga ($P < .05/P < .05$), 5.3/6 mm Hg with brisk walk ($P < .05/P < .05$), and 2.6/3.7 mm Hg with reduction in salt intake ($P < .05/P < .05$); prominent reduction in BP with brisk walking ($P = .0001$) compared with yoga	
Vogler et al, 2011[118]	NRCT, 8 wk	Sedentary elderly > 55 y (n = 38)	Yoga group: Iyenger modified yoga postures in 90-min sessions 1 ×/wk and 20 min of regular home practice (n = 19); no-intervention control group (n = 19)	Preintervention vs postintervention	No change in BP with yoga postintervention	↑ in muscle strength and motion of extremities ($P < .001$) and improvement in physical and mental well-being ($P < .05$) in yoga group
Singh et al, 2011[111]	RCT, 40 d	Rheumatoid arthritis patients (n = 80)	Yoga group: integrated yoga with cleansing practice, asanas, pranayama, meditation, and diet, 90 min/d, 6 d/wk (n = 40); waitlist control group (n = 40)	Preintervention vs postintervention and comparison between the groups	↓ of 7.2/1.6 mm Hg ($P < .001/P < .01$) in SBP/DBP with yoga intervention compared with preintervention; nonsignificant change in waitlist controls; reduction in BP with yoga ($P < .001$) compared with waitlist controls	↓ of 6.2 BPM in pulse rate ($P < .001$); improvement in inflammation in joints and pain intensity
Ebnezar et al, 2011[112]	RCT, 15 d with 3 mo follow up	Osteoarthritis patients (n = 250)	Yoga group: stretching, asanas, relaxation, meditation, yogic philosophy, and physiotherapy in 60-min sessions (n = 125); control group: therapeutic exercise, including loosening, strengthening, and relaxation with music and physiotherapy in 60-min sessions (n = 125)	Preintervention vs postintervention after follow up period and comparison between groups	↓ of 21.3/14.3 mm Hg in SBP/DBP at postintervention after follow-up ($P < .01/P < .01$) in yoga group compared with preintervention; nonsignificant change in controls; reduction in BP with yoga ($P < .001$) compared with controls after postintervention follow-up period	↓ of 9.85 BPM in pulse rate ($P < .01$) in yoga group and 5.6 BPM (nonsignificant) in control group after postintervention follow-up period; improvements in state and trait anxiety ($P < .01$) in both groups at follow-up; reduction in early morning stiffness in both groups

Table 6. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Gopal, 2011[123]	RCT, 12 wk	Normotensive medical students with examination stress (n = 60)	Yoga group: integrated yoga practices with stretching, loosening, asanas, pranayama, and meditation in 35-min session/d (n = 30); no-intervention control group (n = 30)	Preintervention vs postintervention	No change in BP in yoga group, whereas ↑ in SBP 3 mm Hg ($P < .01$) in control group; mean rate pressure product lower in yoga group ($P < .05$) compared with control during postintervention	No change in HR in yoga group, whereas ↑ of 4.67 BPM in HR ($P < .001$) in control group postintervention; ↑ in BR ($P < .01$) in control group: stress score lower in yoga group ($P < .05$) than in controls
Chung et al, 2012[108]	NRCT, 2 wk	Patients from meditation center or medical center, with heterogeneous health conditions (n = 129)	Yoga group: sahaja yoga with breathing practices, exercises, and foot spa together with standard medication (n = 67); control group: conventional medication (n = 62)	Preintervention vs postintervention and comparison between the groups	↓ of 12.3 mm Hg and 6.1 mm Hg in DBP ($P < .001$) in hypertensive individuals with diabetes and hypertensive individuals without diabetes, respectively, with yoga postintervention compared with preintervention; reduction in DBP in yoga group ($P = .004$) compared with hypertensive patients in conventional treatment group	Improvement in all domains of quality of life ($P < .001$) in yoga group compared with controls
Innes et al, 2012[110]	RCT, 8 wk	Postmenopausal overweight women with RLS (n = 75)	Yoga group: Iyenger yoga with 23 restorative poses involving pranayama and relaxation in 90-min sessions 2 ×/wk and home practice (n = 38); control group: educational film and brief discussion with health professional in 90-min sessions 2 ×/wk (n = 37)	Preintervention vs postintervention and comparison between groups	↓ of 20.25/9.38 mm Hg in SBP/DBP ($P < .04/P < .02$) in yoga group postintervention, compared with preintervention; no significant change in controls; reductions in yoga group ($P < .05/P < .03$) compared with controls postintervention	Improvements in multiple domains of mood state and sleep quality, anxiety, and perceived stress in yoga group ($P < .05$) compared with controls postintervention
Tracy et al, 2012[120]	RCT, 8 wk	Sedentary young adult normotensive (n = 21)	Yoga group: bikram yoga in series of 26 guided postures performed in heated and humid studio, 24 sessions each of 90 min (n = 10); no-intervention control group (n = 11)	Preintervention vs postintervention	No change in BP in either group	↑ in flexibility and musculoskeletal fitness in yoga group compared with preintervention; no change in aerobic fitness in yoga group
Kim et al, 2012[121]	RCT, 8 mo	Sedentary premenopausal women (n = 34)	Yoga group: ashtanga yoga, 60 min each session 2 ×/wk (n = 16); control group: daily lifestyle monitored by questionnaire at 2-mo intervals (n = 18)	Preintervention vs postintervention	No change in BP in either group	Improvement in muscle strength ($P < .01$) in yoga group than in controls; no significant change in body flexibility in either group

Abbreviations: BPM = beats per min; HRV = heart rate variability; PMR = progressive muscle relaxation; RLS = restless leg syndrome.

Table 7. Summary of Cohort Studies of Integrated Yoga Practices for Cardiac Risk Factors

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Joseph et al, 1981[41]	Cohort, 3 mo	Normotensive (n = 10)	Integrated yoga—prayer, asana, pranayama, and meditation	Preintervention vs postintervention	↓ of 3/7 mm Hg in SBP/DBP ($P < .01/P < .01$) with yoga postintervention compared with preintervention	↓ of 5 BPM in HR ($P < .001$); ↓ in blood glucose ($P < .05$); ↓ in cholesterol and lipoprotein ($P < .001$)
Telles et al, 1993[126]	Cohort, 3 mo	Normotensive (n = 30)	Residential comprehensive yoga program	Preintervention vs postintervention	↓ of 9.4/7 mm Hg SBP/DBP ($P < .05/P < .001$) with yoga postintervention compared with preintervention	↓ of 3 BPM in HR; ↓ of 0.9 kg in body weight ($P < .05$) postintervention
Sachdeva, 1994[127]	Cohort, 3 mo	Hypertensive and healthy (n = 46); hypertensive group (n = 26); normotensive group (n = 20)	Yogic lifestyle training—asanas, pranayama, meditation, diet, and behavioral modification with lifestyle	Preintervention vs postintervention	Significant progressive reduction in BP in both populations	Significant progressive reduction in body weight; serum cholesterol, and triglyceride levels in both hypertensive and normotensive groups
Damodaran et al, 2002[141]	Cohort, 3 mo	Hypertensive (n = 20)	Comprehensive yogic interventions—postures, breathing, yoga nidra, yoga philosophy, and prayer	Preintervention vs postintervention	↓ of 22/17.4 mm Hg in SBP/DBP with yoga postintervention compared with preintervention (*P* values not provided)	↓ in blood glucose, lipid profile; improvement in subjective well-being; reduction in drug score
Singh et al, 2004[146]	Cohort, 40 d	Type 2 diabetes (n = 24)	13 yoga postures in sequence	Preintervention vs postintervention	↓ of 16/12 mm Hg in SBP/DBP with yoga postintervention (*P* values not provided)	↓ of 8.8 BPM in pulse rate; ↓ of 48.6 and 74.8 mL/dL in fasting and postprandial blood glucose levels, respectively (*P* values not provided)
Sivasankaran et al, 2006[132]	Cohort, 6 wk	Adults with and without CAD risk factors (n = 33)	Integrated yoga practices involving asanas, pranayama, meditation, and relaxation for 90 min/session, 3 d/wk	Preintervention vs postintervention	↓of 5/5 mm Hg in SBP/DBP ($P = .01/P < .01$) with yoga postintervention compared with preintervention; hemodynamic parameters improved to lesser extent in individuals with CAD risk factors	↓ of 9 BPM in HR ($P < .01$); improvement in BMI ($P < .01$) with yoga postintervention; no change in lipid index and glycemic profile
Karunagari, 2007[129]	Cohort, 3 mo	Normotensive (n = 98)	Yoga intervention—sun salutation, pranayama, meditation, relaxation	Preintervention vs postintervention	↓ of 6.2 mm Hg in SBP/DBP ($P < .001/P < .001$) with yoga postintervention	↓ of 7.8 BPM in pulse rate ($P < .001$); ↓in body weight ($P < .001$), serum cholesterol ($P < .001$), and blood sugar ($P < .001$)
Gokal et al, 2007[34]	Cohort, 7 d	Heterogeneous population with CVD risk factors (n = 428)	Yoga intervention—asana, pranayama, mediation	Preintervention vs postintervention	↓ of 8/5 mm Hg in SBP/DBP ($P < .001/P < .001$) with yoga postintervention compared with preintervention	↓ in body weight ($P < .001$), BMI ($P < .001$), blood glucose ($P < .001$), and cholesterol ($P < .001$)
Chen et al, 2008[130]	Cohort, 4 wk	Seniors > 60 y (n = 16)	Complete silver yoga program, 70 min/session	Preintervention vs postintervention	↓ of 18.2 mm Hg in SBP ($P < .02$) with yoga postintervention compared with preintervention	↓ in body fat percentage ($P < .001$)
Thomley et al, 2011[128]	Cohort, 6 wk	Normotensive (n = 50)	Integrated yoga—asana with mindful breath, movement, meditation, and philosophical concepts	Preintervention vs postintervention	↓ of 2.7 mm Hg in DBP ($P < .03$) with yoga postintervention compared with preintervention	↓ in body weight ($P < .001$) and body fat ($P < .001$)
Murthy et al, 2011[142]	Cohort, 21 d with 12 mo of follow-up	Hypertensive medically treated (n = 104)	Integrated yoga with naturopathic treatment modality and dietary management	Preintervention vs postintervention	↓ of 10/5.1 mm Hg in SBP/DBP ($P < .001/P < .001$) with yoga postintervention compared with preintervention	Improvement in lipid index with yoga postintervention; reduction in drug score; 24.56% of participants maintained BP in normal range without medication during follow-up period

Table 7. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Herur et al, 2011[131]	Cohort, 6 mo	Normotensive (n = 50); males (n = 28); females (n = 22)	Warm-up; sun-salutation, meditation, shavasana	Preintervention vs postintervention and comparison between the genders	↓ of 7.1/8.1 mm Hg in SBP/DBP ($P < .001/P < .001$) in males and 7.7/5.5 mm Hg in females ($P < .001/P < .001$); nonsignificant differences between the genders	↓ of 6 BPM and 7.1 BPM in HR ($P < .001/P < .001$) and ↓ of 1.8 kg and 1.9 kg in body weight ($P < .001/P < .001$) for males and females, respectively; improvements in General Health Questionnaire ($P < .001$) for both genders

Abbreviations: CAD = coronary artery disease; BPM = beats per minute.

in BP and the lipid index after 12 months.[142] A further cohort reported improvement in BP, despite unchanged lipid and glycemic profile for volunteers with and without CAD risk factors.[132]

Controlled Studies on Integrated Yoga Practice for Cardiac Risk Factors

The improvements in CVD risk factors seen in cohort studies are consistent with several RCTs and NRCTs involving various yoga practices in hypertensive or normotensive people (Table 8). An early study that examined the effects of yoga postures in healthy individuals suggested that different yoga postures had different effects on BP, with 6 months practicing specific static yoga postures resulting in reductions in BP, blood glucose, and body weight, while the practice of a rhythmic sequence of postures (sun salutations) alone resulted in increases in BP and body weight, despite reductions in blood glucose.[135]

NRCTs of an integrated yoga approach also reported reductions in BP and improvements in metabolic variables for both healthy and diseased populations compared with nonintervention controls. Significant falls in BP, cholesterol, and triglycerides in hypertensive participants were reported after 1 month,[143] while significant falls in BP, pulse rate, and body weight were reported in healthy participants after 2 months.[134] Significant reductions in BP, glycemic index, and BMI were also reported after 3 months of yoga practice in type 2 diabetic individuals.[133] Similarly, a 9-month study reported reductions in SBP, pulse rate, and blood glucose in geriatric participants with HPT and diabetes,[147] and a reduction in blood cholesterol and body weight was seen in hypertensive participants compared with normotensive participants who were attending a 3-month residential yoga training program.[144]

Not all controlled trials of yoga reported reductions in CVD risk factors other than BP. A 2-month study reported reductions in BP but not in other CVD risk factors in hypertensive patients practicing *sudarshan kriya*,[148] and similar results were reported in a 3-month study of normotensive people practicing integrated yoga.[149] The improvements in multiple cardiac risk factors seen in cohort and NRCTs were consistent with the results from RCTs. A significant reduction in BP was reported in a 3-month study in hypertensive patients,[150] and significant reductions in BP and BMI were seen in an 8-week study involving an experimental group practicing yoga techniques, stress reduction, and health management compared with inactive controls.[140] Furthermore, an 11-week study reported significant reductions in BP for a yoga group that were similar to those achieved by a group on antihypertensive medications, with significant reductions in body weight being observed in the yoga group but not in the medication group.[136]

Improvement in cardiovascular reactivity including BP, waist circumference, glycemic control, and lipid profile were reported in two 3-month studies of metabolic-syndrome patients randomly assigned to a yoga intervention compared with unchanged results in those assigned to usual care.[139,137] Similar results were reported in a recent controlled trial of metabolic-syndrome patients randomly assigned either to 16 weeks of yoga or to no intervention.[145] A further 6-month RCT involving CAD patients also found significant reductions in BP and significant improvements in lipid profiles in the yoga group.[33]

In contrast, 3 RCTs ranging from 10 weeks to 20 weeks that compared yoga interventions to active, no-intervention, or usual-care controls found no improvement in BP, glycemic index, or lipid profiles with yoga interventions in HIV infected patients,[138] metabolic syndrome patients,[151] and type 2 diabetic patients.[152]

Studies on Yoga-type Interventions, Biofeedback, and HPT

Biofeedback involves the use of an electronic device to monitor and provide feedback on specific physiological states (Table 9). This technique has been used in several studies of elevated BP where yogic relaxation has been used for behavior modification and stress reduction. In a series of 9 separate studies that spanned a period of over 15 years, Patel et al consistently demonstrated that a combination of yoga relaxation and biofeedback was effective in reducing BP, medication requirements, and cardiovascular risk in hypertensive patients.[65-66,153-159] In these studies, the yoga intervention involved participants being asked to pay attention to their breathing and engage in a yogic relaxation practice that involved mentally relaxing the various parts of the body and then focusing the mind on an object of concentration while receiving feedback on the status of their sympathetic nervous system from a galvanic skin resistance (GSR) device with an audio output.

Table 8. Summary of Controlled Studies of Integrated Yoga Practices for Cardiac Risk Factors

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Udupa et al, 1975[134]	NRCT, 6 mo	Normotensive (n = 10)	Yoga postures—set 1 group: headstand, cobra, locust, and peacock poses (n = 4); set 2 group: shoulder stand, fish, plough, and forward bend (n = 4); sun salutation group (n = 2)	Preintervention vs postintervention	↓ of 9/7 mm Hg in SBP/DBP in set 1; ↓ of 8 mm Hg in DBP in set 2; ↑ of 3/20 mm Hg in BP in sun salutation (*P* values not provided)	↓ in pulse rate; ↓ in body weight 1.3 kg in set 2; ↑2 kg in body weight with sun salutation; ↓ in fasting blood sugar in all (*P* values not provided)
Talukdar et al, 1996[143]	NRCT, 1 mo	Hypertensive (n = 30); healthy, age- and BMI-matched controls (n = 30)	Yoga techniques—visceral cleansing, stretching, postural, and breathing for both groups	Preintervention vs postintervention	↓ of 14.2/12.2 mm Hg in SBP/DBP ($P < .01/P < .01$) in hypertensive group with postintervention compared with preintervention; nonsignificant drop of 4/4.1 mm Hg in healthy group	↑ of 5.3 mg/dL ($P < .05$) in HDL; ↓ in of 23 mg/dL in plasma triglycerides ($P < .01$) and of 14 mg/dL in plasma cholesterol ($P < .01$) in hypertensive group; similar significant trend in healthy group
Schmidt et al, 1997[144]	NRCT, 3 mo	Normotensive (n = 106)	Residential kriya yoga group: complete yogic lifestyle training, including diet, and control group	Preintervention vs postintervention	↓ of 21/13 mm and 15/7 mm Hg in SBP/DBP ($P < .0001$ and $P < .01$) in males and females, respectively	↓ in HR ($P < .005$); ↓ of 5.7 kg in body weight ($P < .02$); ↓ in serum cholesterol and LDL cholesterol ($P < .001$) in men
Murugesan et al, 2000[136]	RCT, 11 wk	Hypertensive (n = 33)	Integrated yoga group: asanas, pranayama, meditation, chanting, and relaxation (n = 11); antihypertensive drug group (n = 11); no-intervention control group (n = 11)	Preintervention vs postintervention	↓of 33.36/26.27 mm Hg in SBP/DBP ($P < .01/P < .01$) with yoga postintervention; ↓ of 23.76/9.91 mm Hg in SBP/DBP ($P < .01/P < .01$) with drugs compared with preintervention; no change in controls	↓ of 27.9 BPM in pulse rate ($P < .01$) with yoga postintervention and 16.8 in BPM ($P < .01$) with drugs postintervention; ↓ of 7.4 kg in body weight ($P < .05$) with yoga postintervention
McCaffrey et al, 2005[140]	RCT, 8 wk	Hypertensive; (n = 61)	Yoga group: breathing and postures, stress reduction techniques, and health information; control group: awareness on hypertension	Preintervention vs postintervention	↓ of 24.9/ 17.51 mm Hg in SBP/DBP ($P < .01/P < .01$) with yoga postintervention compared with preintervention; no change in controls	↓ of 11.85 BPM in HR ($P < .01$); ↓ of 0.24 in BMI ($P < .05$); ↓ in stress scores ($P < .01$) in yoga group compared with preintervention
Khatri et al, 2007[139]	RCT, 3 mo	Metabolic syndrome (n = 101)	Yoga and meditation intervention group (n = 55); usual-care control group (n = 46)	Preintervention vs postintervention	↓ of 15.2/7.7 mm Hg in SBP/DBP ($P < .001/P < .001$) with yoga postintervention compared with preintervention; no change in usual-care controls	↓ in waist circumference, fasting blood sugar, and serum triglycerides ($P < .001$) and improvement in HDL cholesterol ($P < .001$) with yoga postintervention
Cohen et al, 2008[151]	RCT, 10 wk	Metabolic syndrome (n = 26)	Restorative yoga group: poses using props and relaxation techniques (n = 13); waitlist control group (n = 23)	Preintervention vs postintervention and comparison between groups	Nonsignificant change in BP in both groups	Nonsignificant changes in BMI and weight and lipid profile
Govidaraju, 2009[147]	NRCT, 12 wk	Geriatric heterogeneous population (n = 27)	Yoga group: postures, breathing, and mantra chanting (n = 27); physical exercise group: callisthenics, walking, breathing, and relaxation (n = 9); no-intervention control group (n = 9)	Preintervention vs postintervention	Similar significant reduction in SBP in yoga and exercise groups; no change in controls	Significant reduction in pulse rate and blood sugar in yoga and exercise group
Skoro-Kondza et al, 2009[152]	RCT, 3 mo	Type 2 diabetics (n = 59)	Integrated yoga group: yoga techniques in 90-min sessions 2 ×/wk (n = 29); waitlist control group (n = 30)	Preintervention vs postintervention	No change in BP in either group	Nonsignificant change in HbA_{1c}; no change in lipid levels in either group; poor adherence to class attendance

Table 8. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Jain et al, 2010[134]	NRCT, 2 mo	Normotensive (n = 87)	Integrated yoga group: practice of stretching, sun salutation, asanas, pranayama, meditation (n = 57); no-intervention control group (n = 30)	Preintervention vs postintervention	↓ of 4.99/3.47 mm Hg in SBP/DBP ($P < .05/P < .01$) in yoga group compared with preintervention; no change in controls	↓ of 1.72 BPM in pulse ($P < .001$); ↓ of 3.51 kg in body weight ($P < .05$) in yoga group, compared with preintervention
Cade et al, 2010[137]	RCT, 20 wk	HIV patients with CVD risk factors (n = 60)	Yoga intervention group: asana, pranayama, focused gaze, bandhas, and relaxation (n = 34); usual-care control group (n = 26)	Preintervention vs postintervention and comparison between groups	No change in BP in either group	Nonsignificant reduction in body weight after yoga; reduction in lipid/cholesterol parameters in yoga group were similar to usual-care group
Cohen et al, 2011[150]	RCT, 12 wk	Hypertensive (n = 78)	Yoga group: Iyenger yoga involving asana, and pranayama (n = 46); ECU group: motivational and behavioral education with diet and disease awareness (n = 32)	Preintervention vs postintervention	↓ of 6/5 mm Hg in SBP/DBP ($P < .05/P < .01$) with yoga postintervention; nonsignificant drop of ↓ of 4/2 mm Hg in SBP/DBP in ECU group	No change in HR for both groups; no change in BMI with yoga
Yang et al, 2011[137]	RCT, 3 mo	Metabolic syndrome (n = 23)	Viniyasa yoga group: series of postures with breathing and relaxation in 60-min sessions 2 ×/wk, with home practice (n = 12); general health awareness control group (n = 11)	Preintervention vs postintervention and comparison between groups	↓ of 5.2/0.58 mm Hg in SBP/DBP in yoga group compared with controls; nonsignificant different between groups	Prominent reduction in body weight and lipid and glycemic parameters in yoga group compared with control
Hegde et al, 2011[133]	NRCT, 3 mo	Type 2 diabetic patients (n = 123)	Integrated yoga group: practice 3 d/wk (n = 60); control group (n = 63)	Preintervention vs postintervention	Nonsignificant change in BP in yoga group compared with preintervention	Significant improvements in BMI and glycemic parameters in yoga group; improvement in markers of oxidative stress in yoga group
Agte et al, 2011[148]	NRCT, 2 mo	Normotensive and hypertensive (n = 52); hypertensive group (n = 26); normotensive control group (n = 26)	Sudarshan kriya yoga to both groups in 30-min sessions 6 d/wk and in 75-min session 1 ×/wk	Preintervention vs postintervention	↓ of 4.2 mm Hg in DBP ($P < .01$) in hypertensive group compared with preintervention; no change in normotensive group	No significant change in lipid and glycemic parameters in hypertensive group; improvement in markers of oxidative stress ($P < .05$) in hypertensive group
Pal et al, 2011[33]	RCT, 6 mo	CAD patients with other comorbidities (n = 170)	Yoga group: postures with nasal cleansing in 40-min sessions regularly (n = 85); no-intervention control group (n = 85)	Preintervention vs postintervention	↓ of 11.02/8.9 mm Hg in SBP/DBP ($P < .002/P < .009$) in yoga group compared with preintervention; no change in controls	↓ of 4.2 BPM in HR ($P < .0001$); ↓ in BMI ($P < .04$) and total cholesterol and triglycerides ($P < .0001$) in yoga group
Deepa et al, 2012[149]	NRCT, 3 mo	Hypertensive (n = 30)	Yoga intervention group: asana, pranayama, meditation, and yoga nidra together with antihypertensive therapy (n = 15); control group: antihypertensive therapy (n = 15)	Preintervention vs postintervention	↓ of 18.9/13.7 mm Hg in supine SBP/DBP in yoga group and ↓ of 10.3/4.4 mm Hg in supine SBP/DBP in medication therapy group compared with preintervention (*P* values not provided)	↓ of 8.5 BPM in pulse rate in yoga group, compared with preintervention; no improvement in lipid profile in either group (*P* values not provided)
Lee et al, 2012[145]	RCT, 16 wk	Postmenopausal women (n = 16)	Yoga group: yoga posters coordinated with breathing techniques and periods of relaxation (n = 8); no-intervention control group (n = 8)	Preintervention vs postintervention and comparisons between groups	↓of 8.63/8.25 in SBP/DBP ($P < .001/P < .01$) in yoga group compared with preintervention; reduction in BP in yoga group ($P < .001$), compared with controls	↓ in cholesterol ($P < .01$), triglycerides ($P < .05$), and glucose ($P < .01$) in yoga group compared with preintervention

Abbreviations: BPM = beats per minute; HbA_{1c} = glycated hemoglobin.

The first study, which involved hypertensive patients who attended a 30-minute session of biofeedback and yogic relaxation over 3 months, reported a reduction in BP, with a 41% reduction in antihypertensive medication.[153] In a subsequent study of the same duration with a similar intervention, hypertensive patients experienced significant reductions in BP together with a 42% reduction in medication at the end of the follow-up period.[155] Similarly, in a 9-week study with hypertensive patients on antihypertensive medication, Patel et al found that yoga and biofeedback, together with home practice, significantly reduced BP, with a 41% reduction in antihypertensive medication at the end of the follow-up period.[156] In a subsequent crossover study, a similar intervention over 6 weeks was shown to result in significant drops of BP in hypertensive patients.[154]

In addition to improving HPT, the yoga and biofeedback intervention used by Patel et al was demonstrated to improve other coronary risk factors. In a 6-week study, pharmacologically-treated hypertensive patients were found to experience significant reductions in BP and serum cholesterol,[158] and a further study with hypertensive patients using the same intervention also resulted in a significant reduction in BP, together with a significant reduction in cholesterol and triglyceride levels.[159] The same authors performed an unblinded RCT of 204 participants with 2 or more coronary risk factors, in which both groups received general health education, while the treatment group (n = 99) also received weekly 1-hour, group biofeedback and yoga sessions for 8 weeks, together with twice daily home practice and a stress education program. After 8 months, BP fell significantly in all participants in the treatment group, with a more prominent fall in BP in hypertensive participants.[66] A further 4-year follow-up of these participants revealed that reductions in cholesterol and smoking were not maintained while the reductions in BP were maintained in both hypertensive and normotensive participants within the treatment group but not the control group, which also experienced significantly more cardiovascular events.[65] Using a subset of participants from a larger drug trial,[160] the same researchers found significant reductions in BP and cardiovascular events at 8 weeks in a relaxation group compared with a control group that did not receive the relaxation therapy, with the results being maintained after 1 year of follow-up.[157]

In addition to the studies by Patel et al, a number of small studies reported reductions in BP with biofeedback and yogic interventions that involved slow, focused, relaxed breathing.[161-168] These studies included an early case report of a hypertensive patient with periodic angina pectoris treated with various medications, who underwent breath meditation assisted by EMG biofeedback twice per day and experienced significantly lower BP after 8 months of follow-up.[161] Another case study incorporating biofeedback, yogic relaxation, and yogic lifestyle changes reported a reduction in BP after 6 weeks, with the reductions maintained after 6 months despite withdrawal of antihypertensive medication.[165]

Reductions in BP with biofeedback and yoga were also reported in hypertensive patients who underwent 2 months of shavasana training[162] and 4 weeks of yoga relaxation focusing on slow breathing, assisted by instrumental music.[167] These results were consistent with the results of RCTs that found significant falls in BP with 1 month of biofeedback and slow breathing,[164] 2 months of biofeedback and meditation,[163] 2 months of biofeedback and shavasana,[166] and 6 months of thermal biofeedback together with an integrated yoga intervention.[168]

Studies on RESPeRATE-facilitated Breathing and HPT

The RESPeRATE device uses specifically timed music to entrain slow yoga-style breathing < 10 BPM with prolonged exhalation (Table 10). The RESPeRATE device has been used in a number of clinical trials of hypertensive patients, including RCTs,[169-176] an NRCT,[169] cohort studies,[170,171] and a case report.[172]

Reductions in BP have been reported with daily use of RESPeRATE in 2 small cohort studies involving only hypertensive patients. Of these, 1 study reported that use of RESPeRATE resulted in a significant fall in systolic BP for 13 hypertensive patients, measured via 24-hour ambulatory BP monitoring,[170] and the other reported a significant fall in BP for 17 hypertensive patients, measured in clinical as well as home settings.[171] Significant reductions in BP were also reported in an 8-week NRCT involving 48 hypertensive patients using the RESPeRATE compared with 31 control participants who underwent no intervention[169] as well as in a case report of an elderly hypertensive patient with COPD.[172] These results have been further supported by a series of RCTs.

A double-blind, randomized, placebo-controlled trial involving 33 hypertensive patients randomly assigned either to the RESPeRATE (n = 18) or passive music (n = 17) for 8 weeks resulted in significant falls in BP in the treatment group.[173] A similar 8-week, double-blind study of 65 hypertensive patients, randomly assigned either to the RESPeRATE or passive music, reported similar significant reductions in BP that continued after 6 months of follow-up.[174] A further double-blind RCT of 149 hypertensive patients found impressive reductions in BP after 8 weeks, with significant reductions seen only in regular users (>180 min/8 wk).[175] Similarly, an 8-week RCT of 66 NIDDM and hypertensive patients, who randomly received either (1) the RESPeRATE for 15 minutes 3 times per week or (2) usual care, found that the treatment group experienced significant drops in BP with greater reductions being associated with greater compliance and adherence.[176] More recently, another RCT involving 40 borderline hypertensive patients assigned either to the RESPeRATE or spontaneous breathing while repeating the word *one* at each exhalation reported significantly greater reductions in BP in the device-guided breathing group compared with preintervention and to the passive control-breathing groups.[177]

In contrast to the above results, a number of relatively small studies have not shown significant reductions in BP in RESPeRATE users compared with those listening passively

Table 9. Summary of Studies on Biofeedback and Hypertension (N = 649)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Patel, 1973[153]	Cohort, 3 mo	Hypertensive (n = 20)	Biofeedback-aided yogic relaxation	Preintervention vs postintervention	↓ of 26/16 mm Hg in SBP/DBP compared with preintervention (*P* values not provided)	41% reduction in medication
Patel, 1975[155]	NRCT, 3 mo with 12 mo of follow-up	Hypertensive (n = 40)	Biofeedback-aided yogic relaxation group (n = 20); control group (n = 20)	Preintervention vs postintervention	↓of 20.4/14. 2 mm Hg in SBP/DBP ($P < .001/P < .001$) after 3 mo of intervention and stable BP at reduced levels at the follow-up	42% reduction in medication in treatment group
Patel et al, 1975[154]	Crossover RCT, phase 1, 6 wk with 3 mo of follow-up; phase 2, 2 mo of washout and 6 wk of treatment	Hypertensive (n = 34)	Biofeedback-aided yogic relaxation group (n = 17); control group (n = 17)	Preintervention vs postintervention and comparison between interventions	↓ of 26.1/15.2 mm Hg in SBP/DBP (*P* values not provided) in treatment group in phase 1; difference of 17.8/11 mm Hg in SBP/DBP ($P < .005/P < .001$) between groups in phase 1	↓ of 28.1/154 mm Hg in SBP/DBP (*P* values not provided) after 2 mo of washout in control group in phase 2
Patel et al, 1976[156]	NRCT, 9 wk with 6 mo of follow-up	Hypertensive (n = 47)	Biofeedback-aided yogic relaxation group (n = 27); control group, age- and gender-matched: resting on couch (n = 20)	Preintervention vs postintervention	↓ of 17.5/13 mm Hg in SBP/DBP ($P < .001/P < .001$) with treatment; 77% of participants in treatment group benefited at the end of follow-up, despite reduction in medications; no change in controls	41% reduction in medication at follow-up in treatment group
Patel, 1976[158]	Cohort, 6 wk	Medically treated hypertensive (n = 14)	Biofeedback-aided relaxation	Preintervention vs postintervention	↓ of 22.7/ 13.4 mm Hg in SBP/DBP ($P < .001/P < .001$) compared with preintervention	↓ of 24.5 mg/100 mL in serum cholesterol ($P < .001$); body weight remained stable
Patel et al, 1977[159]	NRCT, 6 wk	Hypertensive individuals and in normotensive, smokers, > 10 cigarettes/d (n = 76)	Biofeedback-aided relaxation; hypertensive group (n = 18); smoking group (n = 18); control group (n = 18)	Preintervention vs postintervention	↓ of 18.6/11.2 mm Hg ($P < .0005/P < .0005$) of 8.2/1.9 ($P < .01$)/nonsignificant and of 9.7/7 mm Hg ($P < .002/ P < .005$) in SBP/ DBP for hypertensive, smokers, and normotensive groups, respectively, with yoga postintervention compared with preintervention; no change in control group	↓ in HR ($P < .025$) and ($P < .05$) in hypertensive group and smoking group, respectively; nonsignificant reduction in body weight in both groups; ↓ in cholesterol and triglyceride levels in hypertensive group; significant reduction in smoking in smoking group
Rappaport et al, 1977[161]	Case report, 1 mo with 8 mo of follow-up	Hypertensive (n = 1)	Biofeedback relaxation with breath-focused meditation	Preintervention vs postintervention	↓ of 35/15 mm Hg SBP/DBP at follow-up	
Datey, 1980[166]	NRCT, 8 wk	Hypertensive (n = 20)	Biofeedback and yogic relaxation group (n = 10); control group: resting on couch (n = 10)	Preintervention vs postintervention	Significant reduction in BP in treatment group; no change in controls	33% reduction in drug requirement for treatment group
Hafner, 1982[163]	RCT, 8 wk with 3 mo of follow-up	Hypertensive (n = 21)	Relaxation group: physical relaxation with instructions in wkly session (n = 7); biofeedback group: facilitate relaxation by decreasing physiological arousal in weekly session (n = 8); no-intervention control group (n = 7)	Preintervention vs postintervention	↓ of 14.5/12.6 mm Hg ($P < .05/P < .01$) and 20.8/14.7 mm Hg ($P < .05/P < .01$) in SBP/DBP in relaxation and biofeedback groups, respectively, at the end of follow-up; no change in controls	

Table 9. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Patel et al, 1981[65]; Patel et al, 1985[66]	RCT, unblinded for 8 mo with 4 y of follow-up	Two or more coronary risk factors: hypertensive, elevated serum cholesterol, or smoking > 10 cigarettes/d (n = 204)	Biofeedback-aided relaxation group (n = 99); health-education control group (n = 93)	Preintervention vs postintervention	↓ of 15.3/6.8 mm Hg in SBP/DBP ($P < .001/P < .001$) after 8 mo of follow-up in treatment group; ↓ of 22.4/11.5 mm Hg in SBP/DBP ($P < .001/P < .001$) in subgroup of hypertensive group at the end of follow-up	After 4 yof follow-up, reduction in BP was maintained in hypertensive treatment group
Morga, 1986[162]	Cohort, 2 mo	Hypertensive (n = 8)	Biofeedback-aided yogic relaxation, 20 sessions	Preintervention vs postintervention	↓ of in 24.5/14.3 mm Hg in SBP/DBP, compared with preintervention (*P* values not provided)	
Patel et al, 1988[157]	RCT, 8 wk with home practice and 12 mo of follow-up	Hypertensive (n = 103)	Biofeedback-aided relaxation group (n = 49); no-intervention control group (n = 54)	Preintervention vs postintervention	↓ of 4.9/1.5 mm Hg in SBP/DBP ($P < .0001/P < .015$) at the end of 1 y of follow-up; no change in controls	Reduction in cardiovascular events in treatment group
Brownstein et al, 1989[165]	Case report, 6 wk	Hypertensive (n = 1)	Biofeedback-aided yogic relaxation with incorporation in daily activities of yogic lifestyle techniques.	Preintervention vs postintervention	↓ of 16/6 mm Hg in SBP/DBP after 6 wk, compared with preintervention; BP remained stable at follow-up	
Latha et al, 1991[168]	NRCT, 6 mo, 17 sessions	Hypertensive (n = 14)	Yoga group: asanas, pranayama, and biofeedback-aided relaxation training (n = 7); no-intervention control group (n = 7)	Preintervention vs postintervention	↓of 6.9/5.06 mm Hg in SBP/DBP ($P < .05/P < .01$) compared with preintervention	
Desai, 2001[167]	Cohort, 4 wk	Hypertensive (n = 20)	Biofeedback-aided yogic relaxation, asana practice with instrumental music	Preintervention vs postintervention	↓ of 4.3/9.9 mm Hg in SBP/DBP ($P < .0001/P < .0001$) compared with preintervention	
Wang et al, 2010[164]	RCT, 1 mo with follow-up of 1 mo and 3 mo	Prehypertensive stage postmenopausal women (n = 26)	Biofeedback-aided relaxation and slow breathing (n = 13); control group (n = 13)	Preintervention vs postintervention	↓of 8.4/3.9 mm Hg in SBP/DBP ($P < .001/P < .01$) and stable values at follow-up in experimental group; ↓ of 4.3 mm Hg in SBP ($P < .01$) but no remarkable effect at follow-up in controls	↑ RR interval ($P < .001$) during biofeedback; no remarkable change in HRV

Abbreviations: RR = R within QRS complex of electrocardiogram; HRV = heart rate variability.

Table 10. Summary of Studies on RESPeRATE-facilitated Breathing and Hypertension

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Schein et al, 2001[174]	Double-blind placebo-controlled RCT, 8 wk and 6 mo of follow-up	Hypertensive (n = 61)	Group using modified breathing with RESPeRATE (n = 32); control group: listening to music with self-monitoring of BP (n = 29)	Preintervention vs postintervention and comparison between groups	↓ of 15.2/10.5 mm Hg in SBP/DBP ($P < .035$/ $P < .0002$) in device group and nonsignificant reduction in control group compared with preintervention; postintervention difference between groups in DBP ($P < .008$)	Stable results of BP in device group at follow-up
Grossman et al, 2001[173]	Double-blind placebo-controlled RCT, 8 wk	Hypertensive (n = 30)	Group using modified breathing with RESPeRATE (n = 15); control group: listening to music (n = 15)	Preintervention vs postintervention and comparison between groups	↓ of 7.5/4 mm Hg and 2.9/1.5 mm Hg in SBP/DBP (P values not provided) in active group and control group respectively compared with preintervention; postintervention difference between groups in SBP/DBP ($P < .07$/$P < .02$)	↓ of 8 BPM in HR ($P < .05$) in active group
Rosenthal et al, 2001[170]	Cohort, 8 wk	Hypertensive (n = 13)	Group using modified breathing with RESPeRATE for 15 min and self-monitoring BP	Preintervention vs postintervention	↓ of 7.2 mm Hg in SBP ($P < .01$) in 24-h ambulatory BP while awake	
Viskoper et al, 2003[171]	Cohort, 8 wk	Hypertensive (n = 17)	Group using modified breathing with RESPeRATE for 15 min and self-monitoring BP	Preintervention vs postintervention	↓ of 12.9/6.9 mm Hg in SBP/DBP ($P < .001$/$P < .001$ in clinical settings and ↓ of 6.4/2.6 mm Hg in SBP/DBP ($P < .01$/$P < .05$) in home settings in device group compared with preintervention	
Elliott et al, 2004[175]	Double-blind RCT, 8 wk	Hypertensive (n = 136)	Group using modified breathing with RESPeRATE for 15 min and self-monitoring of BP (n = 79); control group: self-monitoring of BP (n = 57)	Preintervention vs postintervention	↓ of 10.6/3.2 mm Hg in SBP/DBP (P values not provided) in clinical settings in device group, compared with preintervention; ↓ of 8/4.4 mm Hg in SBP/DBP ($P < .005$/ $P < .025$) in high users compared with low users of device; no statistical difference in controls	
Meles, 2004[169]	NRCT, 8 wk	Hypertensive (n = 79)	Group using modified breathing with RESPeRATE for 15 min (n = 48), control group: self-monitoring of blood pressure (n = 31)	Preintervention vs postintervention	↓ of 5.4/3.2 mm Hg in SBP/DBP ($P < .001$/$P < .001$) in home BP compared with preintervention; no significant change in controls	
Elliott et al, 2006[172]	Case report, 8 wk	Hypertensive with COPD and migraine (n = 1)	Group using modified breathing with RESPeRATE 2 ×/d for 15 min and BP monitoring	Preintervention vs postintervention	↓ of 17/14 mm Hg in SBP/DBP ($P < .05$/ $P < .001$)	
Logtenberg et al, 2007[178]	Single-blind RCT, 8 wk	Diabetic hypertensive (n = 30)	Group using modified breathing with RESPeRATE and self-monitoring BP (n = 15); control group: random music and BP monitoring (n = 15)	Preintervention vs postintervention	↓ of 7.8 mm Hg in SBP ($P = .008$) in device group; ↓ of 12.2 mm Hgin SBP ($P < .001$) in control music group compared with preintervention	

Table 10. (continued)

Authors and Year	Design and Duration	Population	Intervention	Comparisons	BP Outcomes	Other Outcomes
Pandic et al, 2008[179]	RCT, 16 wk	Hypertensive (n = 53)	Group using modified breathing with RESPeRATE 2 ×/d for 15 min 3 ×/wk and BP monitoring (n = 31); control group: random music and BP monitoring (n = 22)	Preintervention vs postintervention	↓ of 0.9/1.5 mm Hg in SBP/DBP ($P < .12/P < .001$) in device group and ↓ of 16.8/4.1 mm Hg in SBP/DBP ($P < .001/P < .001$) in music group compared with preintervention	
Schein et al, 2009[176]	RCT, 8 wk	Hypertensive with type 2 diabetes (n = 66)	Group using modified breathing with RESPeRATE (n = 33); control group: continued with medication unchanged (n = 33)	Preintervention vs postintervention	↓ of 10/3.6 mm Hg in SPB/DBP ($P < .001/P < .01$) in device group compared with preintervention	
Altena et al, 2009[180]	Single-blind RCT, 9 wk	Hypertensive (n = 30)	Group using modified breathing with RESPeRATE (n = 15); control group: listening to music and monitoring BP (n = 15)	Comparison between groups	Nonsignificant postintervention difference in BP between the groups	
Anderson et al, 2010[177]	RCT, 4 wk	Hypertensive (n = 40)	Group using modified breathing with RESPeRATE (n = 20); control group: conscious breathing (n = 20)	Preintervention vs postintervention	↓ in SBP ($P < .029$) in treatment group compared with controls in clinic resting	

Abbreviations: COPD = chronic obstructive pulmonary disease; BPM = beats per minute.

to relaxing music. In 1 single-blinded RCT involving 30 diabetic hypertensive patients, 8 weeks of either the RESPeRATE or random music resulted in similar significant reductions in BP in both groups, with no differences between the groups.[178] A similar result was reported in a 16-week RCT of 54 hypertensive patients that found a significant reduction in BP in both the participants who used the RESPeRATE and the participants who listened to slow relaxing music (n = 22).[179] Likewise, significant reductions in BP were noted in hypertensive patients who either used the RESPeRATE or listened to relaxing music, with no significant difference between the groups in a single-blinded RCT.[180]

DISCUSSION

Research performed over the past 40 years with various yoga interventions, including studies with different experimental designs, consistently reported reductions in BP together with reductions in other CVD risk factors such as lipid profile, glycemic index, weight, and HR. The BP reductions reported with yoga were found in diverse populations, including adolescents and the elderly as well as both hypertensive and normotensive populations and unfit and athletic individuals. Yoga was also found to reduce BP in patients taking antihypertensive medications and to reduce medication use while maintaining reduced BP.

Of the 120 studies reviewed, 23 studies (including 12 RCTS) reported no change in BP with yoga practice. Thirteen of these studies[68,81,82,92,100,101,103,104,117-121] involved only a small number of normotensive participants (19 or fewer in each), and 1 cohort study of 64 participants reported no change in BP in young healthy adults despite an increase in cardiac output, stroke volume, and HR after yoga practice.[102] A further NRCT reported no change in BP in 60 diabetic patients after 3 months of yoga practice, despite significant improvements in several CVD risk factors,[133] and similar results were seen in an RCT involving diabetic patients, randomly assigned either to usual care or slow diaphragmatic breathing.[93] No change in BP in diabetic patients was also reported in another RCT that compared an integrated yoga group with poor compliance to a waitlist control group.[152] Three further RCTS showed no change in BP in normotensive participants with mild to moderate stress,[122-124] and another RCT reported no change in BP after 1 year for 35 hypertensive patients who randomly received either 8 weeks of relaxation training or nonspecific counseling.[125] No change in BP with yoga was also reported in a 20-week study involving 60 HIV patients[135] and a 10-week

study involving 26 metabolic syndrome individuals randomly assigned to yoga or usual care.[151]

Many different yoga practices and styles can be adapted or individualized by teachers and practitioners, yet a common element of these practices appears to be the practical application of mind-body integration with the use of the breath as a focus for the link between mind and body. Yoga practices generally lead to a calm, quiet, hypometabolic, meditative state associated with autonomic balance and characterized by positive physiological changes and improved cardio, circulatory, and respiratory function. Therefore, yoga may influence BP through reducing the stress response, increasing parasympathetic activation, and altering baroreceptor sensitivity.

While a large number of published studies have been published, the authors found a great heterogeneity of study designs and yoga practices in the studies examined, and most studies were of poor methodological quality, with small sample sizes and relatively short durations. While 46 RCTs were reviewed, only 4 of these used a placebo group,[85,125,174,173] with most using active or no-intervention controls. Furthermore, few studies of yoga and BP involved long-term follow-up, with only 13 studies being of at least 6 months in duration,[33,66,75,81,97,106,109,114,121,131,135,156,161,168] 4 studies over 1 year,[67,85,117,155] and 2 studies over 3 years.[65,67]

A number of specific yoga practices, such as ANB,[181] yogic relaxation,[69] and slow breathing[182-184] have been shown in experimental laboratory studies to have specific effects on BP. It is not yet clear, however, which aspects of yoga, if any, are more important in reducing BP in specific populations, and research into yoga and HPT is hampered by a lack of standardized practices that are specifically designed as a therapy for HPT. Thus, while the use of equipment such as the RESPeRATE and biofeedback devices have standardized some practices, and attempts have occurred to standardize yoga practices for different populations, such as silver yoga, the vast array of different practices impedes rigorous reporting and standardization of clinical interventions.

The heterogeneity of yoga practices and lack of standardized research make it difficult to formulate clinical guidelines or prescriptions involving yoga. This difficulty is acknowledged in the guidelines of the British Hypertension Society, which state that "interventions to reduce stress management, meditation, yoga, cognitive therapies, breathing exercises, and biofeedback have been shown to result in short-term reductions in BP, but the interventions studied have been so varied, it is difficult to be prescriptive with regard to an effective strategy."[185] The lack of long-term studies, standardized protocols, and conclusive results from meta-analyses has resulted in stress reduction strategies, such as yoga and meditation, being omitted from clinical guidelines on HPT.[5-7,9,10,185] Thus, while these guidelines discuss the importance of lifestyle modification for all hypertensive patients, they focus on aerobic exercise, dietary control, weight reduction, smoking cessation, alcohol reduction, and sodium restriction and do not mention yoga, relaxation, or other stress reduction practices. The Canadian Hypertension Education Program does recommend stress management in the form of cognitive behavioral interventions in hypertensive individuals in whom BP elevation is due to stress but does not consider yoga as a stress management strategy.[7]

CONCLUSION

Yoga practices have been show to be effective in reducing BP in normotensive and hypertensive populations and to be effective as an adjunct therapy in reducing antihypertensive medication use. While many studies on yoga and HPT have been published, most are of poor methodological quality, with small sample sizes and relatively short durations. It appears that yoga is most commonly used as a spiritual and personal development path rather than as a therapy for specific medical conditions, and this has resulted in many different yoga practices being used. The lack of long-term studies, standardized protocols, and conclusive results from meta-analyses makes it difficult to recommend any specific yoga practice for HPT and this has resulted in stress reduction strategies, such as yoga and meditation, being omitted from clinical HPT guidelines. A lack of yoga training and instruction standards also makes it difficult for people to access standardized yoga instruction and primary care physicians may be reluctant to recommended yoga for their patients with HPT if they cannot ensure the quality or relevance of particular yoga practices. Future research needs to focus on high-quality clinical trials with standardized yoga practices and long-term follow-up, together with studies on the mechanisms of action of different practices.

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