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Yoga and Hypertension: A Systematic Review

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Abstract

Lifestyle modification is a cornerstone of hypertension 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 through reducing stress, increasing parasympathetic activation and altering baroreceptor sensitivity; however, despite existing reviews on yoga and cardiovascular disease, diabetes, metabolic syndrome and anxiety suggesting yoga may reduce blood pressure, no comprehensive review has focused on yoga and hypertension.

A systematic review of all published studies on yoga and hypertension was performed revealing 39 cohort studies, 30 non-randomised controlled trials, 48 randomised controlled trials and 3 case reports with durations ranging from 1 week to 4 years and involving a total of 6693 subjects. Most studies reported that yoga effectively reduced blood pressure in both normotensive and hypertensive populations. These studies suggest that yoga could be an effective adjunct therapy for hypertension 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 hypertension. Future research needs to focus on high quality clinical trials along with studies on the mechanisms of action of different yoga practices.

KEYWORDS

Yoga, hypertension, metabolic syndrome, meditation, breathing, asana, shavasana, pranayama, RESPeRATE, biofeedback,

Introduction

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 one-billion people worldwide and account for 13% of deaths, 64 million disability-adjusted life years (DALYs) 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 mmHg, each incremental rise of 20/10mmHg 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 35-40% 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 3-32mmHg and DBP from 2-18mmHg.[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 contributes 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, 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 glycaemic 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 blood pressure.

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 occurred 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 practices did produce significant changes, 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] In 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 4/3.1mmHg.[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 RCT's examining the benefits of relaxation therapies and involving 1198 participants, however, concluded that only weak evidence existed for relaxation therapies producing meaningful reductions in BP in hypertensive participants.[59]

Yoga, Cardiovascular Disease (CVD), 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 that strong evidence existed on the benefits of yoga for the prevention and treatment of coronary heart disease in conjunction with normal medication, but the evidence that 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, 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 for the practice of yoga by 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 have attested to the benefits of yoga as a treatment for hypertension. One systematically reviewed the benefits of yoga for HPT. It included 19 studies published between the years 1972 and 2012, with 902 participants, and reported that yoga was less costly than pharmacological therapies, and despite the existence of few RCTS, found that yoga appeared to serve as alternate to drugs in controlling hypertension.[63] Another review of 6 RCTs and one 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 occurred, 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.0

METHODS

The authors conducted a thorough primary search for published medical literature, using the terms yoga, yogic, *Shavasana, Pranayama,* breathing, or breath, with the keywords BP or HPT. Studies for this review were

identified by a systematic cross search in the scientific databases SCOPUS, PUBMED, PSYCINFO, CINAHL, and Science Direct. 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, nonrandomized control trials (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, 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 blood pressure (n = 13) and/or blood-pressure 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 assess critically 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 one week to 4 years of follow-up, with numbers of participants ranging from one to 428. The total population assessed in these studies was 6693, including both healthy and disease groups and involving 389 elderly and 299 adolescent participants. In total, the reviewed studies represent a population that 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 1-10 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 reductions in BP in untreated hypertensive participants 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 participants 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.[65] 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.[66] 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.[67]

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[68] and in healthy participants after 3 months of practice of either *Shavasana* or Transcendental Meditation[69] as well as 3 weeks of practice of either *Hatha* Yoga or Progressive Muscle Relaxation (PMR).[70] Yoga relaxation practices have also been shown to reduce BP significantly in RCTs of 8 days involving hypertensive participants[71] and of 8 months in women with monaural irregularities,[72] with BP remaining unchanged in control groups. A 6-month study showed that relaxation practices may be particularly important in reducing BP, finding that normotensive elderly participants practicing *Silver Yoga,* either with or without relaxation, had similar improvements in physical fitness compared to waiting-list controls. but only the relaxation group experienced significant reductions in SBP.[73] Similarly, a 4-week NRCT reported significant falls in BP in hypertensive participants when relaxation practices were conjoined with drug therapy (n = 50), although BP in healthy participants practicing relaxation (n = 10) remained unchanged.[74]

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).[75, 76] An 8-week study also reported similar significant reductions in resting BP after a single 15-minute session of alternate nostril breathing as well as progressive BP reductions with longer practice.[77] Additionally a recent 12-week study reported significant reductions in BP in normotensive participants studying *Mukh Bhastrika pranamyama*. [78]

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.[79] Similarly, a study of 3 months with 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 alternate nostril breathing (ANB).[80]

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.[81, 82] Reductions in SBP were also observed with slow breathing in a placebo-

controlled trial of hypertensive participants 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/min.[83] 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 participants, with BP reductions being more prominent after slow breathing.[84]

Additionally, 3 NRCTs, one of 6 weeks and two of 8 weeks, reported a reduction in BP in normotensive participants[85-87]. 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.[86] Significant falls in BP were also reported with ANB after 8 weeks when compared to sun salutation[87] and after 6 weeks when compared to no intervention.[85] A more recent 3-month NRCT reported significant reductions in BP with yogic-breathing manoeuvres comprising *Ujjayi, Bhastrika*, chanting, and breath-focused meditation practices.[88] 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.[89] However, 2 RCTs of 3 months reported no change in BP in normotensive adolescents practicing various different types of slow *pranayamic* breathing[90] and in diabetic participants practicing slow diaphragmatic breathing, despite significant improvement in CVD risk factors.[91]

Integrated Yoga Practices 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,[92] 2 months,[93] 3 months,[94] and 6 months.[95] Significant reductions in BP with breathing and postural practices were also observed in 13 hypertensive participants after 4 weeks[96] and in 10 hypertensive participants and 17 hypertensive participants with coronary artery disease (CAD), after 5 weeks but not in participants with CAD alone.[97] In contrast to those findings, 4 studies involving normotensive participants reported no change in BP.[98-101] Of these, two small studies of 8 people reported no change in BP after 2 weeks of practicing a single yoga posture (shoulder stand posture)[98] and 4 weeks of practicing a defined sequence of postures, breathing, and chanting (*Shanti Kriya*).[99] 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[100] nor in an 11-week study of 17 middle and elderly yoga practitioners undertaking intense yoga training.[101] 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.[102]

Integrated Practices 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 as compared to a lesser, nonsignificant reduction in BP with *Hatha* yoga.[103] Two controlled trials involving healthy normotensive people reported reductions in BP after 10 weeks[104] and 6 weeks, trial also reported significant reductions in BP with *Sahaj* yoga in hypertensive participants with or without type 2 diabetes (n = 67), as compared to participants with standard medical treatment [105] as compared to controls receiving no intervention. A recent controlled (n = 62), with the reductions being more prominent among the diabetic participants.[106] A further 3-month, RCT of 30 healthy soldiers reported reductions in BP for those adhering to a *Hatha* yogic lifestyle, including dietary measures, as compared to 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, as compared with participants taking antidepressant medication.[107] A 2-month RCT of gentle *Iyengar* yoga in postmenopausal women with restless leg

syndrome also found reduction in BP, as compared to a control group receiving instruction on general awareness through personal interaction and visual aids.[108]

Similarly, BP reductions were reported in participants with rheumatoid arthritis after 40 days of yoga, as compared to waitlist controls[109] and in osteoarthritis participants after 3 months of follow-up preceded by 15 days of yoga, as compared to therapeutic exercise.[110] Additionally, a 10-week RCT reported reductions in BP in an elderly group practicing yoga in weekly sessions with home practice, as compared to a control group engaged in physical entertainment, with more prominent reductions observed in a subgroup attending class and regularly practicing at home.[111]

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.[112] 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, as compared to controls receiving no intervention.[113]

A number of studies have compared yoga groups to no-intervention or active-intervention controls, and one study reported reductions in BP with a yoga intervention similar to a head-tilt active control group.[114] 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[115] or after 8 weeks of *Iyengar* yogic techniques using various props,[116] as compared to control participants maintaining their regular lifestyles.

Seven RCT's reported no change in BP in yoga groups, as compared to 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[117]; (2) after 8 weeks of *Bikram* yoga in sedentary, normotensive young adults, despite significant improvement in body flexibility[118]; and (3) after 8 months of *Ashtanga* yoga in sedentary, normotensive, premenopausal women, despite improvements in muscle strength.[119] 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.[120] 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[121] and in a 16-week study of *Kundalini* yoga in a population under mild stress.[122] A further RCT involving mild hypertensive participants reported no reduction in BP after one year of yoga relaxation or nonspecific counseling.[123]

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,[124-135, 33, 136, 34, 137, 138] hypercholesterolemia,[125, 139, 127, 140-142, 137, 136, 135, 33, 143, 34, 41] and hyperglycaemia[127, 144, 139, 41, 131, 133, 145, 137, 135, 143, 136, 34].

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,[124] 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).[128] More recently, a reduction in BP was reported in 2 studies, each with 50 healthy volunteers, one after 6 weeks with significant improvement in body fat percentage and weight. [126] [and one after 6 months with significant reduction in HR and body weight.[129]

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 [125] and improvements in BP and lipids along with glycaemic index were reported in studies of healthy normotensive [41, 127] and in a population with metabolic abnormalities.[34]. Improvement in BP and better glycaemic control was also reported in diabetic individuals after 40 days of yoga practice.[144]

.Cohort studies have also reported reductions in use of antihypertensive medications together with improvements in BP, lipid profile, and glycaemic index after 3 months[139] and in BP and the lipid index after 12 months.[140] A further cohort reported improvement in BP, despite unchanged lipid and glycaemic profile for volunteers with and without CAD risk factors.[130]

Controlled Studies on Integrated Yoga Practice for Cardiac Risk Factors

The improvements in CVD risk factors seen in cohort studies were consistent in several RCTs and NRCTs with involvement in various yoga practices in hypertensive or normotensive people (Table 8). An early study examined the effects of yoga postures in healthy individuals. It suggested that different yoga postures had different effects on BP with 6 months of practice in specific static yoga postures, resulting in reductions in BP, blood glucose, and body weight, while practice of a rhythmic sequence of postures (sun salutations) alone resulted in increases in BP and body weight, despite reductions in blood glucose.[133]

NRCTs also reported reductions in BP and improvements in metabolic variables for both healthy and diseased populations when using an integrated yoga approach, as compared to nonintervention controls. Significant falls in BP, cholesterol, and triglycerides in hypertensive participants were reported after one month,[141] while significant falls in BP, pulse rate, and body weight were reported in healthy participants after 2 months.[132] Significant reductions in BP, glycaemic index, and BMI were also reported after 3 months of yoga practice in type II diabetic individuals.[131] Similarly, a 9-month study reported reductions in SBP, pulse rate, and blood glucose in geriatric participants with hypertension and diabetes,[145] and a reduction in blood cholesterol and body weight was seen in hypertensive participants compared to normotensive participants who were attending a 3-month residential yoga training program.[142] Not all controlled trials studying 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 participants practicing *Sudarshan* kriya,[146] and similar results were reported in a 3-month study of normotensive people practicing integrated yoga.[147] 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 participants,[148] 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, as compared to inactive controls.[138] 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.[134]

Improvement in cardiovascular reactivity including BP, waist circumference, glycaemic control, and lipid profile were reported in two 3-month studies of metabolic-syndrome participants randomly assigned to a yoga intervention, as compared to unchanged results in those assigned to usual care.[137, 135] Similar results were reported in a recent controlled trial of metabolic-syndrome participants randomly assigned either to 16 weeks of yoga or to no intervention.[143] A further 6-month RCT involving CAD participants 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, glycaemic index, or lipid profiles with yoga interventions in HIV infected participants,[136] metabolic syndrome participants,[149] and type II diabetic participants.[150]

Studies on Yoga-type Interventions, Biofeedback, and Hypertension

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 blood pressure 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 participants.[151-159] 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.

The first study, which involved hypertensive participants who attended a half-hour session of biofeedback and yogic relaxation over 3 months, reported a reduction in BP, with a 41% reduction in antihypertensive medication.[151] In a subsequent study of the same duration with a similar intervention, hypertensive participants experienced significant reductions in BP together with a 42% reduction in medication at the end of the follow-up period.[153] Similarly, in a 9-week study with hypertensive participants 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.[154] In a subsequent crossover study, a similar intervention over 6 weeks was shown to result in significant drops of BP in hypertensive participants.[152]

In addition to improving hypertension, 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 participants were found to experience significant reductions in BP and serum cholesterol,[157] and a further study with hypertensive participants using the same intervention also resulted in a significant reduction in BP, together with a significant reduction in cholesterol and triglyceride levels.[158] 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 one-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.[159] 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.[155] 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, as compared to a control group that did not receive the relaxation therapy, with the results being maintained after one year of follow-up.[156]

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 participant with periodic angina pectoris treated with various medications, who underwent breath meditation assisted by EMG biofeedback twice a 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 participants 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 one 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 Hypertension

The RESPeRATE device is a piece of equipment that uses specifically timed music to entrain slow yoga-style breathing (<10bpm), with prolonged exhalation (Table 10). The RESPeRATE device has been a participant in a number of clinical trials including RCTs,[169-176] an NRCT,[169] cohort studies,[170, 171] and a case report.[172] These studies have generally reported significant reductions in BP with the RESPeRATE device.

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

A double-blind, randomized, placebo-controlled trial involving 33 hypertensive participants 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 participants 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 participants found impressive reductions in BP after 8 weeks, with significant reductions seen only in regular users (>180 minutes/8 weeks).[175] Similarly, an 8-week RCT of 66 NIDDM and hypertensive participants, who randomly received either the RESPeRATE for 15 minutes 3 times per week or 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 participants 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 as compared to pre-intervention 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, as compared to those listening passively to relaxing music. In one single-blinded RCT involving 30 diabetic hypertensive participants, 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 participants 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 participants 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, glycaemic index, weight, and HR. The BP reductions reported with yoga were found in diverse populations, including both hypertensive and normotensive populations, as well as in unfit and athletic individuals, and adolescents and the elderly. Yoga was also found to reduce BP in participants 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[67, 90, 99, 98, 115, 79, 118, 101, 116, 80, 117, 102, 119] involved only a small number of normotensive participants, 19 or fewer in each, and one cohort study of 64 participants reported no change in BP in young healthy adults despite an increase in cardiac output, stoke volume, and HR after yoga practice.[100] A further NRCT reported no change in BP in 60 diabetic participants after 3 months of yoga practice, despite significant improvements in several CVD risk factors,[131] and similar results were seen in an RCT involving diabetic participants, randomly assigned either to usual care or slow diaphragmatic breathing.[91] No change in BP in diabetic participants was also reported in another RCT that compared an integrated yoga group with poor compliance to a waitlist control group.[150] Three further RCTS showed no change in BP in normotensive participants with mild to moderate stress,[120-122] and another RCT reported no change in BP after one year for 35 hypertensive participants who randomly received either 8 weeks of relaxation training or nonspecific counseling.[123] No change in BP with yoga was also reported in a 20-week study involving 60 HIV participants[135]and a 10-week study involving 26 metabolic-syndrome individuals randomly assigned to yoga or usual care.[149]

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 is likely to influence BP through reducing the stress response, increasing parasympathetic activation, and altering baroreceptor sensitivity.

While a large number of published studies have occurred, 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 occurred, only 4 used a placebo group,[123, 83, 174, 173] with most using active or no-intervention controls, and few long-term studies of yoga and BP took place, with only 13 studies of at least 6 months duration,[95, 104, 112, 79, 133, 33, 154, 161, 159, 129, 119, 107, 73, 168] 4 studies over one year,[83, 65, 153, 115] and 2 studies over 3 years.[155, 65]

A number of specific yoga practices, such as ANB,[181] yogic relaxation,[66] 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 makes 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 (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.[185, 7, 6, 9, 5, 10] Thus, while these guidelines discuss the importance of lifestyle modification for all hypertensive participants, 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 shown to reduce BP in normotensive and hypertensive populations and have been used to various degrees as an adjunct therapy for HPT as well as a way to reduce antihypertensive medication use. While many studies have been done, 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 practices and purposes. The lack of long-term studies, standardized protocols, and conclusive results from meta-analyses makes it difficult to recommend any specific yoga practice for hypertension 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 standardised 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 standardised yoga practices and long-term follow-up, together with studies on the mechanisms of action of different practices.

Figure 1: Flowchart of Study Search and

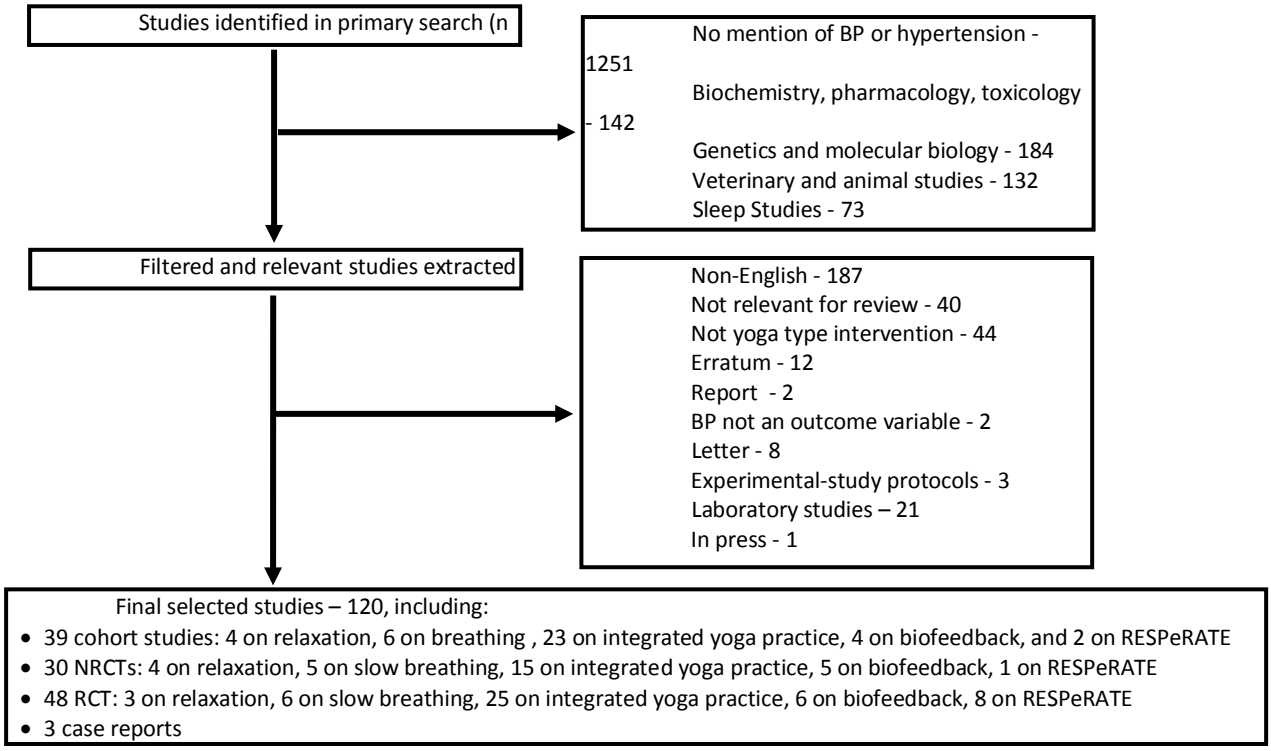

Figure 2. Summary of randomized controlled trials (RCTs) categorized according to type of yogic intervention, direction of result—change or no change in BP, sample size—box height, duration—box width, and length of follow-up—shaded box's width).

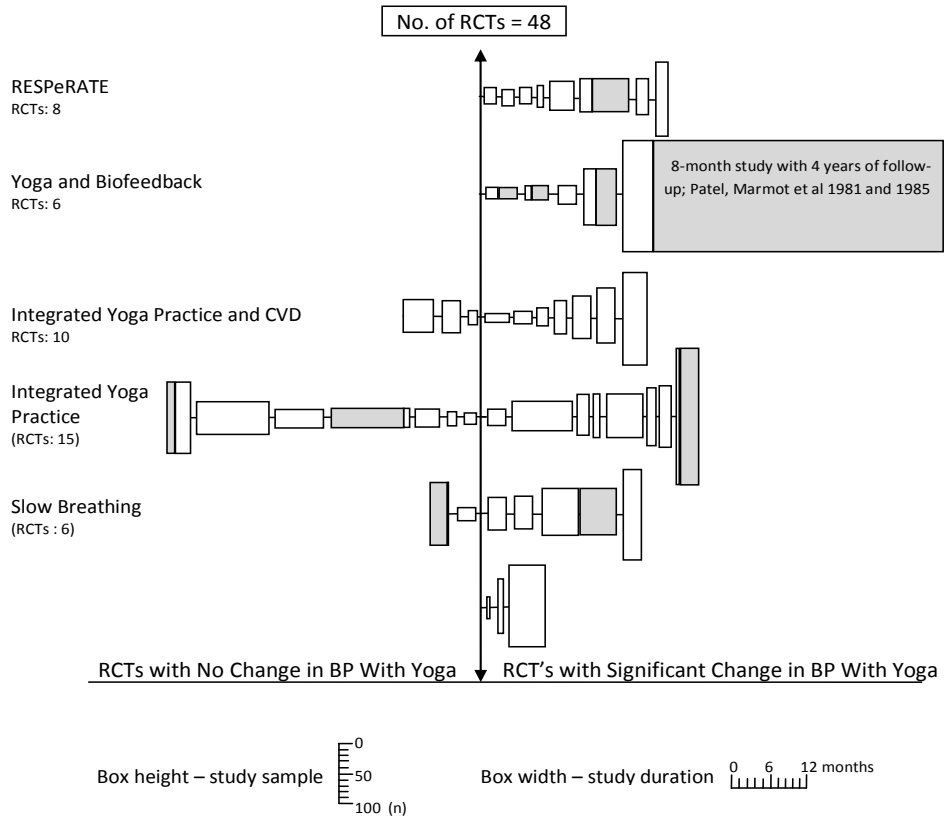

Table 1: Summary of Yogic Relaxation Cohort Studies Reporting Changes in Blood Pressure (BP) With Yogic Relaxation Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Datey, Deshmukh et al, 1969[26]	Cohort, 3 weeks	Hypertensive (n = 47); untreated group (n = 10); group on antihypertensive medication (n = 22); group poorly controlled with drugs (n = 15)	*Shavasana*	Pre-intervention versus postintervention	↓ 27 mmHg in mean BP (p<.05) for untreated group and ↓ 10mmHg in mean BP (p<.05) for group with hypertension poorly controlled with medication, as compared to pre-intervention	↓ of 32% (p<.05) for group with hypertension controlled with medication and 29% ↓ for group with hypertension poorly controlled with medication
Sundar, Agrawal et al, 1984[65]	Cohort, 6 months with 3 years of follow-up	Hypertensive (n = 25); untreated hypertensive group (n = 20); medically treated hypertensive group (n = 5)	*Shavasana* twice a day	Pre-intervention versus postintervention	↓ of 14/11.6mmHg in SBP/DBP (p<.001/p<.001) for untreated hypertensive group and ↓ of 31.2/18.8mmHg (p.001/p<.001) for treated hypertensive group, as compared to pre-intervention	BP was maintained in regular practitioners in follow-up period despite 33.3% to 80% reduction in antihypertensive drug use with mean reduction of 47.6%
Madanmoha n. Udupa, 2002[67]	Cohort, 7 days	Healthy normotensive group (n = 10)	*Shavasana*	Pre-intervention versus post-intervention	No change in resting BP	↓ of 4.4 BPM in resting HR (p<.05)
Sharma, Mahajan et al, 2007[66]	Cohort, 4 weeks	Healthy normotensive group (n = 60)	*Shavasana*	Pre-intervention versus post-intervention	↓ of 6.5/3.02mmHg in SBP/DBP (p<001/p<.001) after 10 minutes of practice; greater reduction after 4 weeks (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

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

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Bagga and Gandhi, 1983[69]	NRCT, 12 weeks, 20 minutes each day	Healthy normotensive (n = 18)	Transcendental Meditation (n = 6); *Shavasana* (n = 6); controls: relaxed, closed-eye sitting (n = 6)	Pre-intervention versus postintervention	↓ of 8.94/4.6mmHg in SBP/DBP (p<.01/p<.05) after TM, ↓7.27/2.4mmHg (p<.05/p<.05) after *Shavasna* compared to pre-intervention; no change in controls	↓ of 9.97 BPM[§] in HR (p<.01) and of 7.9BPM (p<.05) after TM and *Shavasana* respectively compared to pre-intervention
Chaudhary, Bhatnagar et al, 1988[74]	NRCT, 4 weeks	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)	Pre-intervention versus postintervention	↓ of in BP 25.18/ 25.16mmHg in relaxation group compared to pre-intervention (p values not provided); no change in controls	
Cusumano and Robinson, 1993[70]	RCT′ 3 weeks, 3 sessions per week of 80 minutes each	Healthy female normotensive (n = 95)	Yoga (YP) group (n = 45); progressive muscle relaxation (PMR) group (n=45);	Pre-intervention versus postintervention and comparisons between the groups	↓ of 3.49mmHg mean BP in yoga group and ↓ of 2.17mmHg in mean BP in PMR group compared to pre-intervention (p values not provided); no significant differences between the interventions	↓ of 3.22 in BPM & 4.13 in BPM in HR in YP and PMR groups, respectively (p values not provided)
Broota, Varma et al, 1995[71]	RCT, 8 days	Hypertensive (n = 40)	*Shavasana* (n = 10); *Baroota* relaxation group (n = 10); Progressive muscle relaxation (PM) group (n = 10); controls: no intervention (n = 10)	Pre-intervention versus postintervention and comparisons between the groups	Significant reduction in BP (p<.01) with all relaxation therapies compared to pre-intervention; no change in controls	*Shavasana* was most effective and prominent in reduction, followed by *Baroota* and PMR
Madanmohan, 2004[68]	NRCT, 6 weeks	Healthy normotensive adolescents (n = 43)	*Shavasana* group (n = 26); controls: no intervention (n = 17)	Pre-intervention versus postintervention	↓ of 5/4mmHg in SBP/DBP (p<.05/p<.03) in *Shavasna* group compared to pre-intervention; no change in controls	↓of 5 BPM in HR (p<.01)

Chen, Chen et al, 2008[73]	NRCT, 24 weeks	Elderly seniors >60 years (n = 176)	*Silver yoga* group with guided relaxation: 70 minutes each session for 3 days/week (n = 53); *Silver yoga* group without guided relaxation: 55 minutes each session for 3 times/week (n = 53); waitlist controls (n = 66)	Pre-intervention versus postintervention	Significant reduction in SBP (p<.05) in yoga group with guided relaxation compared to pre-intervention; 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)	**Abbreviations**: NRCT, nonrandomized controlled trial; SBP, systolic blood pressure; DBP, diastolic blood pressure; BPM, breaths per minute; HR, heart rate; RCT, randomized controlled trial; LF, low frequency; HF, high frequency
Monika, Singh et al, 2012[72]	RCT, 6 months	Females with symptoms of menstrual irregularity (n = 150)	Yoga *nidra* group: 40 minutes each session for 5 days/week (n = 75); Controls: regular medication (n = 75)	Pre-intervention versus postintervention	↓ of 2.98/4.22mmHg in SBP/DBP (p<.01/p<.0005) after yoga *nidra* compared to pre-intervention; nonsignificant change in controls with medication	↓ of 3.93BPM in HR (p<.01) and improvement in symptoms of menstrual irregularities after yoga *nidra* compared to pre-intervention; positive improvement in LF/HF ratio after yoga *nidra*	

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

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Udupa, Singh et al, 1975[79]	Cohort, 6 months	Normotensive (n = 6)	Yoga breathing, *Ujjayi and Bhastrika*	Pre-intervention versus 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, Gogate et al, 1988[76]	Cohort, 4 weeks	Normotensive (n = 10)	ANB for 30-minutes per session	Pre-intervention versus postintervention	↓ of 8.8/5.16mmHg in resting SBP/DBP (p<.01/p<.05), as compared to pre-intervention	No change in resting HR
Srivastava, Jain et al, 2005[77]	Cohort, 8 weeks	Normotensive (n = 40)	ANB for 15-minutes per session	Pre-intervention versus postintervention	↓ of 6.4mmHg and 3.6mmHg (p<.0001 and p<.01) in SBP in males in females, as compared to pre-intervention	↓ of 12.55 and 11.7 BPM in HR males and females, (p<.001 and p<.001), respectively, after 8 weeks
Upadhyay Dhungel, Malhotra et al, 2008[75]	Cohort, 4 weeks	Normotensive (n = 36)	ANB for 15 minutes per session	Pre-intervention versus postintervention	↓ of 4.16mmHg in DBP (p<.001), as compared to pre-intervention	↓ of 3 BPM in pulse rate (p<.001) and improvement in respiratory variables (p<.001)
Veerabhadrappa, Baljoshi et al, 2011[78]	Cohort, 3 months	Normotensive males (n = 50)	*Mukh Bhastrika*	Pre-intervention versus postintervention	↓ of 4.72 mmHg in supine mean BP (p<.001), and ↓ of 2.32mmHg in standing mean BP (p<.01) compared to pre-intervention	↓ of 13.4 BPM (p<.001) in HR
Jaju, Dikshit et al, 2011[80]	Cohort , 3 months	Normotensive with COPD (n = 11); healthy normotensive (n = 6)	ANB with extended retention (6:6:6) for 30 minutes in each session for 5 days/week	Pre-intervention versus 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: ANB, alternative nostril breathing; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; BPM, beats per minute; COPD, chronic obstructive pulmonary disease; LF, low frequency; HF, high frequency

Table 4: Summary of Slow Breathing Controlled Trials Reporting Changes in BP with Slow Breathing Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Udupa, Madanmohan et al, 2003[90]	RCT, 3 months	Normotensive adolescents (n = 24)	Pranayama group: alternate nostril breathing, *Mukh Bhastrika, Pranav, Savitri* (n = 12); controls: no intervention (n = 12)	Pre-intervention versus postintervention	No change in BP in either group	↓ of 6.16 BPM in HR (p<.01) in *pranayama* group
Madanmohan, Udupa et al, 2005[89]	NRCT, 3 weeks	Normotensive (n = 30)	Slow breathing group with breath hold: *savitri pranayama,* 2:1:2:1 (n = 15); fast breathing group: *Bhastrika* (n = 15)	Pre-intervention versus postintervention	↓ of 2.93mmHg in DBP (p<.05) with slow breathing, as compared to pre-intervention; nonsignificant increase in DBP with fast breathing, as compared to pre-intervention	Nonsignificant decrease in HR with slow breathing; ↑ of 6.44 BPM in HR (p<.05) with fast breathing
Jain, Srivastava et al, 2005[86]	NRCT, 8 weeks	Normotensive (n = 40)	Right Nostril Breathing (RNB) group (n=20) and Left Nostril Breathing (LNB) group (n = 20): each with 15-minute sessions daily for 8 weeks	Pre-intervention versus postintervention	↓ of 6/5mmHg in SBP/DBP (p<.001/p<. 05) in males and of 5 mmHg in DBP (p<.01) in females with RNB, as compared to pre-intervention; ↓ of 9/7mmHg in SBP/DBP (p<.001/p<.01) in males and 8/5mmHg (p<.01/p<.05) in females with LNB, as compared to pre-intervention;	↓ of 12 BPM and 3 BPM in HR, (p<.01) and (p<.05) in males and females, respectively, after RNB; ↓ of 16BPM and 13 BPM in HR (p<.001) and (p<.05) in males and females, respectively, after LNB
Barnes, Pendergrast et al, 2008[81]	RCT, 3 months	Borderline hypertensive adolescents (n = 66)	Breath awareness meditation (BAM) group: slow deep relaxed and focused diaphragmatic breathing (n = 20); Health Education Control (HEC) group: education on BP, weight reduction and diet—salt and fat reduction (n = 46)	Pre-intervention versus postintervention	↓ of 4.7mmHg in SBP (p<.05) during school and 4.8 mmHg (p<.01) during night in BAM group, as compared to pre-intervention; no statistically significant change in HEC	↓ of 6.7BPM in HR (p<.02) during school and 2.2BPM (p<.03) at night with BAM
Mourya, Mahajan et al, 2009[84]	RCT, 3 months	Hypertensive (n = 60)	Slow breathing group: 5-6bpm, occluding either nostril alternatively (n = 20); fast breathing group: short and quick 60mpb for one minute followed by 3	Pre-intervention versus postintervention	Significant fall in SBP/DBP with slow (p<.0001/p<.0001) and fast breathing (p<.004/.003)	

			minutes pause (n = 20); Controls: no intervention (n = 20)			
Modesti, P.A., et al, 2010[83]	RCT, Placebo Controlled, 6 months, with 6 months of follow-up	Hypertensive (n = 86)	Slow breathing group: synchronized with music up to 4-6 BPM as per Buteko method, 10 minutes and 20 minutes 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)	Pre-intervention versus postintervention and comparison between groups	↓ of 7.4mmHg in office SBP (p<.05); ↓ of 7.5mmHg in 24-hr ambulatory SBP (p<.0001) at follow-up, as compared to pre-intervention; no change for music relaxation and book reading; reduction in slow breathing group (p<.001), as compared to slow music and book reading	No change in drug score for any group
Fareedabanu and Gorkal, 2010[87]	NRCT, 8 weeks	Normotensive (n=40)	Alternate Nostril Breathing (ANB) group: 20 minutes daily, (n = 20); Sun Salutation group: 10 cycles in 20 minutes (n = 20)	Pre-intervention versus postintervention	↓ of 5.15/1.05mmHg in resting SBP/DBP (p<.05/p<.05) with ANB, as compared to pre-intervention; non significant change with sun salutation	↓ of 4.73BPM in HR (p<.05) with ANB and nonsignificant change with sun salutation
Singh, Gaurav et al, 2011[85]	NRCT, 6 weeks	Normotensive (n=30)	Alternate nostril breathing (ABN) group: 30-minute session daily (n = 30); Controls: no intervention (n = 15)	Pre-intervention versus postintervention	↓ of 4.94mmHg in SBP (p<.05), with ANB, as compared to pre-intervention; no change in controls	↓ of 10.1BPM in HR (p<.01) with ANB
Malik, Shah et al, 2011[88]	NRCT, 3 months	Normotensive (n=150)	Yoga Breathing group: *Ujjayi, Bhastrika, Humsa* chanting, and *Shavasana* meditation (n = 100); controls: no intervention (n=50)	Pre-intervention versus postintervention	↓ of 8.6mmHg in SBP (p<.0001) after yoga breathing, as compared to pre-intervention; 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, Barnes et al, 2011[82]	RCT, 3 months	Borderline hypertensive adolescents (n=166)	Breath awareness meditation (BAM) group: slow, deep, relaxed, and focused diaphragmatic breathing (n = 53); Life style training (LST) group (n = 69); Health education (HEC) controls:	Comparison between groups	↓ of 3.1mmHg in SBP with BAM (p<.01) compared to LST and (p<.02), as compared to HEC; ↓ of 2mmHg in DBP with BAM (p<.03) compared to LST and 1.7mmHg (nonsignificant) compared to HEC	Reduction of 3.2BPM in HR with BAM (p<.01) compared to LST

			education on BP, weight reduction and diet—salt and fat reduction (n = 44)			
Hegde, Adhikari et al, 2012[91]	RCT, 3 months with follow-up	Type II diabetes (n=123)	Diaphragmatic breathing (DB) group: slow, deep, mindful, relaxed breathing, either in supine or sitting position for 20-minute session twice daily (n = 60); controls: standard care including information about diet and exercise (n = 63)	Pre-intervention versus postintervention follow-up and comparison between groups	Nonsignificant change in BP with DB at follow-up, as compared to pre-intervention; no significant difference between the groups	Improvement in glycaemic index—fasting and postprandial ($p<.001$ and .007, respectively) at follow-up with DB compared to pre-intervention; improvement in BMI ($p<.003$) and WHR ($p<.001$) with DB compared to control at follow-up

Abbreviations: RCT, randomized controlled trial; BPM, beats per minute; HR, heart rate; NRCT, nonrandomized controlled trials; DBP, diastolic blood pressure; SBP, systolic blood pressure; PEFR, peak expiratory flow rate; WHR, waist hip ratio

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

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Lakshmikantha, Alagesan et al, 1979[97]	Cohort , 5 weeks	Hypertensive and CAD patients (n = 44); hypertensive group (n = 10); CAD + hypertensive group (n = 17); CAD group (n = 17)]	Yoga, postural and relaxation	Pre-intervention versus postintervention	↓ of 9.7/8.8mmHg in SBP/DBP (p<.05/p<.01) in hypertensive group and ↓ of 12.9/8.47mmHg (p<.05/p<.01) in hypertensive + CAD group post yoga and relaxation, as compared to pre-intervention; no change in CAD patients	
Anantharaman and Kabir, 1984[94]	Cohort , 3 months	Normotensive (n = 17)	Integrated yoga: postural practices coordinated with *pranayamic* breathing movement	Pre-intervention versus postintervention	↓ of 3.2/4.4mmHg in SBP/DBP (p<.05/p<.05) with yoga intervention, as compared to pre-intervention	↓ of 5.93 BPM in pulse rate (p<.05)
Satyanarayana, Rajeswari et al, 1992[99]	Cohort, 30 days	Normotensive (n = 8)	*Shanti Kriya:* yogic postures incorporated with breathing, meditation, chanting, and relaxation)	Pre-intervention versus postintervention	No significant change in BP	No change in pulse rate
Konar, Latha et al, 2000[98]	Cohort, 2 weeks	Normotensive (n=8)	*Sarvangasana* (shoulder stand posture)	Pre-intervention versus postintervention	No significant change in BP	↓ in resting HR (p<.02)
Madanmohan, Udupa et al, 2004[93]	Cohort, 2 months	Normotensive (n= 21)	Yoga postures and yoga breathing	Pre-intervention versus postintervention	↓ of 2.9/6.19mmHg in resting SBP/DBP (p<.01/p<.001) with yoga intervention, as compared to Pre-intervention; ↓ of 5.95mmHg in MAP (p<.001)	↓ of 5.62BPM in resting HR (p<.01)
Vijayalakshmi , Madanmoha	Cohort, 4 weeks	Hypertensive (n = 13)	Yoga postures and yoga breathing	Pre-intervention versus	↓ of 21/11.93mmHg in SBP/DBP (p<.001/p<.001) and ↓ of 12.46mmHg in MAP (p<.001) after yoga intervention, as	↓ of 10.15 BPM in HR (p<.0001) after yoga intervention

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
n et al, 2004[96]				postintervention	compared to pre-intervention	
	Ramos-Jiménez, Hernández-Torres et al, 2009[101]	Normotensive female yoga practitioners practicing yogic exercises of low aerobic intensity for >3 years (n = 17)	Intensive *Hatha* yoga program with dynamic stretching, postures, breathing ,and meditation, 90 minutes each session 5 days/week	Pre-intervention versus postintervention	No change in BP	Improvement in $VO2_{max}$ ($p<.05$)
Herur, Kolagi et al, 2010[95]	Cohort, 6 months	Normotensive (n = 50)	Yoga: Stretching, prayers, *Asana pranayama*, meditation, relaxation	Pre-intervention versus postintervention	↓ of 8/6mmHgmmHg in SBP/DBP ($p<.001$/$p<.001$) with yoga postintervention, as compared to pre-intervention	↓of 6.5BPM in HR ($p<.001$); improvement in general health questionnaire ($p<.001$) with yoga postintervention
Ankad, Herur et al, 2011[92]	Cohort, 2 weeks	Normotensive (n = 50)	Yoga: *Pranayama* and Meditation	Pre-intervention versus postintervention	↓ of 3.8/3.08mmHg in SBP/DBP ($p<.001$/$p<.001$) postintervention, as compared to pre-intervention	↓ of 3.68BPM in pulse rate ($p<.001$)
Dolgoff-Kaspar, Baldwin et al, 2012[102]	Cohort, 4 weeks	Patients awaiting organ transplant (n = 6)	Laughter yoga: 7 sessions of 20 minutes with breathing and stretching and laughter exercise with rhythmic clapping and guided meditation	Pre-intervention versus postintervention	No change in BP with yoga postintervention	Improvement in time domain analysis of HRV; improvement on the scores of profile and mood states
Parshad, Richards et al, 2012[100]	Cohort, 6 weeks	Normotensive (n = 64)	Yoga: *asanas pranayama* and meditation once per week for 60 minutes and regular 10-minute practice of mediation at home	Pre-intervention versus postintervention	No change in BP post yoga intervention compared to Pre-intervention	↑ in HR ($p<.05$), CO ($p<.001$), SV ($p<.01$) and CO($p<.01$) and ↓ in IBI ($p<.01$) with yoga postintervention, as compared to pre-intervention

Abbreviations: CAD, coronary artery disease; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure BPM, beats per minute; HR, heart rate; $VO2_{max}$,maximal oxygen uptake; HRV, heart rate variability; CO, cardiac output ; SV, stroke volume; IBI, inter beat interval

Table 6: Summary of Integrated Practices Controlled Studies Reporting Changes in BP with Integrated Yoga Practices

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Haber, 1983[111]	RCT, 10 weeks	Healthy elderly population (white and black) from two community centers (n = 106)	Yoga group: gentle yoga twice weekly with in class and in home practice (n = 63) Control group: either film series or art activity (n = 43)	Pre-intervention versus postintervention and comparisons between the groups	↓ of 12/7mmHg 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 7/4mmHg 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 control (p<.05); nonsignificant difference in black elders compared to controls	Improved psychological well-being in white elderly community compared to black elderly community (p<.05)
Devi, Chansauria et al, 1986[107]	RCT, 6 months	Depressive (n = 80)	*Kundalini* yoga group: *Asana, pranayama* and concentration on *Chakras*, 60 minutes daily (n = 40); group using usual antidepressant drugs (n = 40)	Pre-intervention versus postintervention	↓ of 8/8mmHg in SBP/DBP (p<01/p<.001) with yoga, as compared to pre-intervention; ↓ of 11/9 mmHg in SBP/DBP (p<.001/p<.001) with drug therapy compared to pre-intervention	↓ in pulse 13 BPM (p<.001) and 14 BPM (p<.001) with yoga and drugs, respectively
Van Montfrans, Karemaker et al, 1990[123]	RCT, placebo control, 8 weeks, with 12 months of follow-up	Hypertensive (n = 35)	Yoga group: muscle relaxation, yoga exercise and stress management (n = 18); control group: sit and relax twice a day (n = 17)	Pre-intervention versus postintervention at the end of follow-up period	No change in BP in both groups	

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Raju, Madhavi et al, 1994[115]	NRCT, 24 months	Normotensive (n = 28)	Yoga group: breathing and relaxation with physical workouts (n = 14); control group: physical workouts (n = 14)	Pre-intervention versus postintervention	No significant change in resting BP in both groups, as compared to pre-intervention	No change in resting HR
Bowman, Clayton et al, 1997[117]	RCT, 6 weeks	Sedentary normotensive elderly >62 years (n = 26)	Yoga group: stretching postures and breathing with 20 minutes relaxation (n = 12); aerobic exercise group: 40-minute session of warm-up, workload to increase heart rate, and warm-down training (n = 14)	Pre-intervention versus postintervention	No significant change in BP in either group; reduction in BP prominent in aerobic group compared to yoga group	↓ of 8 BPM in HR (p<.05) in yoga group compared to pre-intervention; no significant change in HR in aerobic group
Selvamurty, Sridharan et al, 1998[114]	NRCT, 3 weeks	Hypertensive (n = 30)	Yoga group: specific yoga posture of head up or down tilt for 30 minutes daily (n = 20); control group: 70^0 head tilt for 30 minutes daily (n = 10)	Pre-intervention versus postintervention	↓ of 29/17mmHg in SBP/DBP (p<.001/p<.001) in yoga group and ↓ of 21/21mmHg in tilt group (p<.001/p<.00) postintervention, as compared to pre-intervention	↓ of 7 BPM in HR (p<.01) in yoga group and 9 BPM in tilt group (p<.05), as compared to their respective pre-intervention values; progressive improvement in baroreflex sensitivity in both groups
Ray, Mukhopadhyaya et al, 2001[104]	RCT crossover trial, 10 months	Normotensive (n = 54)	Comprehensive yoga intervention group: *Asanas, pranayama, mudra*, and cleansing practices (n = 28); waitlist control group; continued similar exercises postintervention for 5 months (n = 26)	Pre-intervention versus postintervention	↓ of 10.17mmHg and 11.2 mmHg in SBP (p<. 001) for males and females, respectively, of yoga group, as compared to pre-intervention; ↓ of 8.75mmHg and 8.4mmHg in SBP (P<001 and p<.05) in males and females, respectively, of waitlist control, as compared to pre-intervention; nonsignificant change in DBP in both groups	Significant reduction in HR in both groups

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
(Harinath, Malhotra et al, 2004[31]	RCT, 3 months	Normotensive (n = 30)	Integrated yoga group: *Asanas, pranayama*, meditation in 60-minute sessions twice daily (n = 15); aerobic exercise group: body flexibility, slow running, games in 60-minute sessions twice daily (n = 15)	Pre-intervention versus postintervention	↓ of 9.2/9.6mmHg in SPP/DBP (p<.001/p<.001) in yoga group, as compared to pre-intervention; no change in BP of aerobic group	No significant change in HR
Cowen and Adams, 2005[103]	NRCT, 6 weeks	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 minutes twice weekly	Pre-intervention versus 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, Ingvarsson et al, 2006[122]	RCT, 16 weeks	Normotensive with mild stress (n = 33)	*Kundalini* yoga group: Balancing body movements, breathing, meditation, and diet awareness (n = 16); CBT group: psycho-education management techniques for stress, anger, and mindful relaxation (n = 17)	Pre-intervention versus postintervention	Nonsignificant change in BP in both groups	Significant reduction in HR (p<.07) in yoga group, as compared to pre-intervention; improvement in psychological markers of stress in both groups, as compared to their respective pre-intervention values

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
(Smith, Hancock et al, 2007[120]	RCT, 10 weeks, with 6 weeks follow-up	Normotensive with mild stress (n = 131)	Yoga Intervention group: *Asana*, *pranayama*, relaxation, and meditation (n = 68); Progressive Muscle Relaxation (PMR) group: audio tape with music in 10- to 15-minute weekly sessions (n = 63)	Pre-intervention versus 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 weeks
Madanmohan , Mahadevan et al, 2008[105]	NRCT, 6 weeks	Normotensive (n = 46)	Yoga intervention group: *Asana, pranayama* and relaxation (n = 23); No intervention control (n = 23)	Pre-intervention versus postintervention	↓ of 12mmHG and 7mmHg in DBP (p=.02/p=.03 in males and females, respectively, with yoga postintervention, as compared to pre-intervention; no change in controls	No change in HR; improvement in muscle strength and endurance (p<.05)
Niranjan, Bhagyalakshmi et al, 2009[112]	NRCT, 9 months	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)	Pre-intervention versus postintervention and comparison between groups	↓ of 7.57/6.12mmHg in SBP/DBP (p<.05/p<.05) in exercise group and ↓ of 7.3/6.94mmHg(p<.05/p<.05) in exercise group and yoga + exercise group postintervention, as compared to pre-intervention; nonsignificant drop in yoga group	Improved HRV in exercise group (p<.001) and yoga + exercise (p<.001) group ; nonsignificant change in yoga group, as compared to Pre-intervention
(Saptharishi, Soudarssanane et al, 2009[113]	RCT, 8 weeks	Hypertensive (n = 113)	Yoga group: 30-45 min/day for 5 days (n = 27); brisk walk group: 50-60 minutes, 4 days/week (n = 28); salt reduction group: half previous intake (n = 28); no intervention control group (n = 30)	Pre-intervention versus postintervention and comparison between groups	↓ of 2/2.6mmHg in SBP/DBP with yoga (p<.05/p<.05), 5.3/6mmHg with brisk walk (p<.05/p<.05), and 2.6/3.7mmHg with reduction in salt intake (p<.05/p<.05); prominent reduction in BP with brisk walking (p=.0001), as compared to yoga	

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Vogler, O'Hara et al, 2011[116]	NRCT, 8 weeks	Sedentary elderly >55 year (n = 38)	Yoga group: *Iyenger* modified yoga postures in 90-minute sessions once weekly and 20 minutes of regular home practice (n = 19); no-intervention control group (n = 19)	Pre-intervention versus 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, Bhandari et al, 2011[109]	RCT, 40 days	Rheumatoid arthritis patients (n = 80)	Yoga group: integrated yoga with cleansing practice, *asanas, pranayama,* meditation, and diet, 90 minutes per day, 6 days/week (n = 40); waitlist control group (n = 40)	Pre-intervention versus postintervention and comparison between the groups	↓ of 7.2/1.6 mmHg (p<.001/p<.01) in SBP/DBP with yoga intervention, as compared to pre-intervention; nonsignificant change in waitlist controls; reduction in BP with yoga (p<.001), as compared to waitlist controls	↓ of 6.2 BPM in pulse rate (p<.001); improvement in inflammation in joints and pain intensity
Ebnezar, Nagarathna et al, 2011[110]	RCT, 15 days with 3 months follow up	Osteoarthritis patients (n = 250)	Yoga group: stretching, *asanas,* relaxation, meditation, yogic philosophy, and physiotherapy in 60=minute sessions (n = 125); control group: therapeutic exercise, including loosening, strengthening, and relaxation with music and physiotherapy in 60-minute sessions (n = 125)	Pre-intervention versus postintervention after follow up period and comparison between the groups	↓ of 21.3/14.3mmHg in SBP/DBP at postintervention after follow-up (p<.01/p<.01) in yoga group, as compared to pre-intervention; nonsignificant change in controls; Reduction in BP with yoga (p<.001) as compared to controls after post-intervention 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

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Gopal, A., 2011[121]	RCT, 12 weeks	Normotensive medical students with examination stress (n = 60)	Yoga group (YG): integrated yoga practices with stretching, loosening, *asanas, pranayama,* and meditation in 35- minute session daily (n = 30); no-intervention control group (n = 30)	Pre-intervention versus postintervention	No change in BP in yoga group, whereas ↑ in SBP 3mmHg (p<.01) in control group; mean-rate pressure product lower in yoga group (p<.05), as compared to 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, Brooks et al, 2012[106]	NRCT, 2 weeks	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)	Pre-intervention versus postintervention and comparison between the groups	↓ of 12.3mmHg and 6.1mmHg in DBP (p<.001 in hypertensive individuals with diabetes and hypertensive individuals without diabetes , respectively, with yoga postintervention, as compared to pre-intervention; reduction in DBP in yoga group (p<.004), as compared to hypertensive patients in conventional treatment group	Greater improvement in all domains of quality of life (p<.001) in yoga group as compared to controls
Innes and Selfe, 2012[108]	RCT, 8 weeks	Postmenopausal overweight women with restless leg syndrome (RLS) (n = 75)	Yoga group*: Iyenger* yoga with 23 restorative poses involving pranayama and relaxation in 90-minute sessions twice weekly and home practice (n = 38); control group: educational film and brief discussion with health professional in 90-minute sessions twice weekly (n = 37)	Pre-intervention versus postintervention and comparison between groups	↓ of 20.25/9.38mmHg in SBP/DBP (p<.04/p<.02) in yoga group postintervention, as compared to pre-intervention; no significant change in controls;larger reductions in yoga group (p<.05/p<.03)as compared to controls postintervention	Improvements in multiple domains of mood state and sleep quality, anxiety and perceived stress in yoga group (p<.05), as compared to controls postintervention
Tracy and Hart, 2012[118]	RCT, 8 weeks	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 minutes (n = 10); no-intervention control group (n = 11)	Pre-intervention versus postintervention	No change in BP in either group	↑ in flexibility and musculoskeletal fitness in yoga group, a compared to pre-intervention; no change in aerobic fitness in yoga group

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Kim, Bemben et al, 2012[119]	RCT, 8 months	Sedentary premenopausal women (n = 34)	Yoga group*: Ashtanga* yoga, 60 minutes each session 2 times/week (n = 16); control group: daily lifestyle monitored by questionnaire at 2-month intervals (n = 18)	Pre-intervention versus 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: RCT, randomized controlled trial; SBP, systolic blood pressure; DBP, diastolic blood pressure; BPM, beats per minute; HR, heart rate; HRV, heart rate variability;

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

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Joseph, Sridharan et al, 1981[41]	Cohort , 3 months	Normotensive (n = 10)	Integrated yoga— prayer, *asana, pranayama,* and meditation	Pre-intervention versus postintervention	↓ of 3/7mmHg in SBP/DBP (p<.01/p<.01) with yoga postintervention, as compared to pre-intervention	↓ of 5 BPM in HR (p<.001); ↓ in blood glucose(p<.05); ↓ in cholesterol and lipoprotein (p<.001)
Telles, Nagarathna et al,1993[124]	Cohort, 3 months	Normotensive (n = 30)	Residential comprehensive yoga program	Pre-intervention versus postintervention	↓ of 9.4/7mmHg SBP/DBP (p<.05/p<.001) with yoga postintervention, as compared to pre-intervention	↓ of 3BPM in HR; ↓ of 0.9kg in body weight (p<.05) postintervention
Sachdeva, 1994[125]	Cohort , 3 months	Hypertensive and healthy (n = 46); hypertensive group (n = 26); normotensive group (n = 20)	Yogic lifestyle training— *asanas, pranayama*, meditation, diet, and behavioural modification with lifestyle	Pre-intervention versus 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, Malathi et al, 2002[139]	Cohort, 3 months	Hypertensive (n = 20)	Comprehensive yogic interventions—postures, breathing, yoga *nidra*, yoga philosophy, and prayer	Pre-intervention versus postintervention	↓ of 22/17.4mmHg in SBP/DBP with yoga postintervention, as compared to pre-intervention (p values not provided)	↓ in blood glucose, lipid profile; improvement in subjective well-being; reduction in drug score
Singh, Malhotra et al, 2004[144]	Cohort, 40 days	Type II DM (n = 24)	13 yoga postures in sequence	Pre-intervention versus postintervention	↓ of 16/12mmHg in SBP/DBP with yoga postintervention (p values not provided)	↓ of 8.8BPM in pulse rate ; ↓ of 48.6 and 74.8ml/dl in fasting and postprandial blood-glucose levels, respectively (p values not provided)
Sivasankaran, Pollard-Quintner et al, 2006[130]	Cohort, 6 weeks	Adults with and without CAD risk factors (n = 33)	Integrated yoga practices involving *asanas, pranayama*, meditation, and relaxation for 90 minutes at each session, 3 days/ week	Pre-intervention versus postintervention	↓of 5/5mmHg in SBP/DBP (P =01/p<.01) with yoga postintervention, as compared to pre-intervention; hemodynamic parameters improved to lesser extent in individuals with CAD risk factors	↓of 9BPM in HR (p<.01); improvement in BMI (p<.01) with yoga postintervention; no change in lipid index and glycaemic profile
Karunagari,	Cohort ,	Normotensive (n =	Yoga intervention—sun salutation, *pranayama*,	Pre-intervention versus	↓ of 6.2mmHg in SBP/DBP (p<001/p<.001)	↓ of 7.8 BPM in pulse rate (p<.001); ↓in body weight

2007[127]	3 months	98)	meditation, relaxation	postintervention	with yoga postintervention	(p<.001), serum cholesterol (p<.001), and blood sugar (p<.001)
Gokal, Shillito et al, 2007[34]	Cohort, 7 days	Heterogeneous population with CVD risk factors (n = 428)	Yoga intervention—*asana, pranayama*, mediation	Pre-intervention versus postintervention	↓ of 8/5mmHg in SBP/DBP (p<.001/p<.001) with yoga postintervention, as compared to pre-intervention	↓in body weight (p<.001), BMI (p<.001), blood glucose (p<.001), and cholesterol (p<.001)
Chen and Tseng, 2008[128]	Cohort, 4 weeks	Seniors >60 years (n = 16)	Complete silver yoga program, 70 minutes per session	Pre-intervention versus postintervention	↓ of 18.2mmHg in SBP (p<.02) with yoga postintervention. as compared to pre-intervention;	↓in body fat percentage (p<.001)
Thomley, Ray et al, 2011[126]	Cohort, 6 weeks	Normotensive (n = 50)	Integrated yoga—*asana* with mindful breath, movement, meditation, and philosophical concepts	Pre-intervention versus postintervention	↓of 2.7mmHg in DBP (p= .03) with yoga postintervention, as compared to re-intervention	↓ in body weight (p<.001) and body fat (p<.001)
Murthy, Rao et al, 2011[140]	Cohort, 21 days with 12 months of follow-up	Hypertensive medically treated (n = 104)	Integrated yoga with naturopathic treatment modality and dietary management	Pre-intervention versus postintervention	↓ of 10/5.1mmHg in SBP/DBP (p<.001/p<.001) with yoga postintervention, as compared to pre-intervention	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
Herur, Kolagi et al, 2011[129]	Cohort, 6 months	Normotensive (n = 50); males (n = 28); females (n = 22)	Warm-up; sun-salutation, meditation, *shavasana*	Pre-intervention versus postintervention and comparison between the genders	↓ of 7.1/8.1mmHg in SBP/DBP (p<.001/p<.001) in males and 7.7/5.5mmHg in females (p<.001/p<.001); nonsignificant differences between the genders	↓ of 6 BPM and 7.1BPM in HR (p<.001 & p<.001) and ↓ of 1.8kg and 1.9k in body weight (p<.001 & p<.001)) for males and females, respectively; improvements in General Health Questionnaire (p<.001) for both genders

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; BPM, beats per minute; HR, heart rate; CAD, coronary artery disease; BMI, body mass index

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

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Udupa, Singh et al, 1975[133]	NRCT, 6 months	Normotensive (n = 10)	Yoga postures- set 1 group: headstand, cobra, locust and peacock pose (n = 4); set2 group:-shoulder stand, fish, plough, and forward bend (n = 4); sun salutation group (n = 2)	Pre-intervention versus postintervention	↓ of 9/7mmHg in SBP/DBP in set 1; ↓of 8mmHg in DBP in set 2; ↑ of 3/20mmHg 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, Verma et al, 1996[141]	NRCT, one month	Hypertensive (n = 30); healthy, age- and BMI- matched controls (n = 30)]	Yoga Techniques—visceral cleansing, stretching, postural, and breathing, to both groups	Pre-intervention versus postintervention	↓ of 14.2/ 12.2mmHg in SBP/DBP (p<.01/p<.01) in hypertensive group with postintervention, as compared to pre-intervention; nonsignificant drop of 4/4.1mmHg in healthy group	↑ of 5.3mg/dl (p<.05) in HDL; ↓ in of 23mg/dl in plasma triglycerides (p<.01) and of 14mg/dl in plasma cholesterol (p<.01) in hypertensive group; similar significant trend in healthy group
Schmidt, Wijga et al, 1997[142]	NRCT, 3 months	Normotensive (n = 106)	Residential *Kriya* yoga group: complete yogic lifestyle training, including diet, and control group	Pre-intervention versus postintervention	↓ of 21/13mm and 15/7mmHg in SBP/DBP (p<.0001 and p< .01) in males and females, respectively	↓ in HR (p<.005); ↓ of 5.7kg in body weight (p<.02); ↓ in serum cholesterol and LDL cholesterol (p<.001) in men
(Murugesan, Govindarajulu et al, 2000[134]	RCT, 11 weeks	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)	Pre-intervention versus postintervention	↓of 33.36/26.27mmHg in SBP/DBP (p<.01/p<.01) with yoga postintervention; ↓of 23.76/9.91mmHg in SBP/DBP (p<.01/p<.01) with drugs, as compared to pre-intervention; 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 post intervention; ↓ of 7.4 kg in body weight (p<.05) with yoga postintervention
McCaffrey, Ruknui et al. 2005[138]	RCT, 8 weeks	Hypertensive; (n = 61)	Yoga group: breathing and postures, stress reduction techniques, and health information; control group: awareness on hypertension	Pre-intervention versus postintervention	↓ of 24.9/ 17.51mmHg in SBP/DBP (p<.01/p<.01) with yoga postintervention, as compared to pre-intervention; 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 to pre-intervention

Khatri, Mathur et al. 2007[137]	RCT, 3 months	Metabolic syndrome (n = 101)	Yoga and meditation intervention group (n = 55); usual-care control group (n = 46)	Pre-intervention versus postintervention	↓ of 15.2/7.7mmHg in SBP/DBP- (p<.001/p<.001) with yoga postintervention, as compared to pre-intervention; 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, Chang et al, 2008[149]	RCT. 10 weeks	Metabolic syndrome (n = 26)	Restorative yoga group: poses using props and relaxation techniques (n = 13); waitlist control group (n = 23)	Pre-intervention versus postintervention and comparison between groups	Nonsignificant change in BP in both groups	Nonsignificant changes in BMI and weight and lipid profile
Govidaraju, 2009[145] *(Govidaraju 2009)*	NRCT, 12 weeks	Geriatric heterogeneous population (n = 27)	Yoga group : postures, breathing, and mantra chanting (n = 27); physical exercise group: calisthenics, walking, breathing, and relaxation (n = 9); no-intervention control group (n = 9)	Pre-intervention versus 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, Tai et al, 2009[150]	RCT, 3 months	Type II diabetics (n = 59)	Integrated yoga group: yoga techniques in 90-minute sessions twice a week (n = 29); waitlist control group (n = 30)	Pre-intervention versus postintervention	No change in BP in either group	Nonsignificant change in HbA1c; no change in lipid levels in either group; poor adherence to class attendance
Jain, Jain et al, 2010[132]	NRCT, 2 months	Normotensive (n = 87)	Integrated yoga group: practice of stretching, sun salutation, *asanas, pranayama*, meditation (n = 57); no-intervention control group (n = 30)	Pre-intervention versus postintervention	↓ of 4.99/3.47mmHg in SBP/DBP- (p<.05/p<.01) in yoga group, as compared to pre-intervention; no change in controls	↓ of 1.72 BPM in pulse (p<.001); ↓ of 3.51kg in body weight (p<.05) in yoga group, as compared to pre-intervention
Cade, Reeds et al, 2010[136]	RCT, 20 weeks	HIV patients with CVD risk factors (n=60)	Yoga intervention group: *Asana, pranayama*, focused gaze, *Bandhas,* and relaxation (n =3 4); usual-care control group (n = 26	Pre-intervention versus 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, Bloedon et al. 2011[148]	RCT, 12 weeks	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)	Pre-intervention versus postintervention	↓ of 6/5mmHg in SBP/DBP (p<.05/p<.01) with yoga postintervention; nonsignificant drop of ↓ of 4/2mmHg in SBP/DBP in ECU group	No change in HR for both groups; no change in BMI with yoga
Yang, Bernardo et al, 2011[135]	RCT, 3 months	Metabolic syndrome (n=23)	*Viniyasa* yoga group: series of postures with breathing and relaxation in 60-minute sessions twice weekly, with home practice (n =12); general-health-awareness control group (n = 11)	Pre- intervention versus postintrervention and omparison between groups	↓ of 5.2/0.58mmHg in SBP/DBP in yoga group, as compared to controls; nonsignificnta different between groups	Prominent reduction in body weight and lipid and glycaemic parameters in yoga group, as compared to control
Hegde, Adhikari et al, 2011[131]	NRCT, 3 months	Type II Diabetic patients (n=123)	Integrated yoga group: practice 3 days/week (n = 60); control group (n = 63)	Pre-intervention versus postintervention	Nonsignificant change in BP in yoga group, as compared to pre-intervention	Significant improvements in BMI and glycaemic parameters in yoga group; improvement in markers of oxidative stress in yoga group
Agte, Jahagirdar et al. 2011[146]	NRCT, 2 months	Normotensive and hypertensive (n = 52); hypertensive group (n=26); normotensive control group (n = 26)	*Sudarshan Kriya* yoga to both groups in 30- minute sessions 6 days/weeks and in 75-minute session once a week	Pre-intervention versus postintervention	↓ of 4.2mmHg in DBP (p<.01) in hypertensive group, as compared to pre-intervention; no change in normotensive group	No significant change in lipid and glycaemic parameters in hypertensive group; improvement in markers of oxidative stress (p<.05) in hypertensive group
Pal, Srivastava et al, 2011[33]	RCT, 6 months	CAD patients with other comorbidities (n = 170)	Yoga group: postures with nasal cleansing in 40-minute sessions regularly (n = 85); no-intervention control group (n = 85)	Pre-intervention versus postintervention	↓ of 11.02/8.9 mmHg in SBP/DBP (p<.002/ p<.009) in yoga group, as compared to pre-intervention; no change in controls	↓ of 4.2BPM in HR (p<.0001); ↓ in BMI (p<.04) and total cholesterol and triglycerides (p<.0001) in yoga group
Deepa, Sethu et al, 2012[147]	NRCT, 3 months	Hypertensive (n = 30)	Yoga intervention group: *Asana, Pranayama*, meditation; and yoga *nidra* together with	Pre-intervention versus postintervention	↓ of 18.9/13.7mmHg in supine SBP/DBP in yoga group and ↓ of 10.3/4.4mmHg in supine SBP/DBP in medication therapy group, as compared to pre-intervention (p	↓ of 8.5BPM in pulse rate in yoga group, as compared to pre-intervention; no improvement in lipid profile in either group (p

			antihypertensive therapy (n = 15); Control group: antihypertensive therapy (n = 15)		values not provided)	values not provided)
Lee, Kim et al, 2012[143]	RCT, 16 weeks	Postmenopausal women (n = 16)	Yoga group: yoga posters coordinated with breathing techniques and periods of relaxation (n = 8); no-intervention control group (n = 8)	Pre-intervention versus postintervention and comparisons between groups	↓of 8.63/8.25 in SBP/DBP (p<.001/p<.01) in yoga group, as compared to pre-intervention; reduction in BP in yoga group (p<.001), as compared to controls	↓ in cholesterol (p<.01), triglycerides (p<.05), and glucose (p<.01) in yoga group, as compared to pre-intervention

Abbreviations: NRCT, nonrandomized controlled trial; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein; HR, heart rate; LDL, low-density lipoprotein; RCT , randomized controlled trial; BPM, beats per minute; BMI, body mass index; HbA1c, glycated haemoglobin

Table 9: Summary of Studies on Yoga-type Interventions, Biofeedback, and Hypertension

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
Patel, 1973[151]	Cohort, 3 months	Hypertensive (n=20)	Biofeedback-aided yogic relaxation	Pre-intervention versus postintervention	↓ of 26/16mmHg in SBP/DBP as compared to pre-intervention (p values not provided)	41% reduction in medication
Patel, 1975[153]	NRCT' 3 months with 12 months of follow-up	Hypertensive (n=40)	Biofeedback-aided yogic relaxation group (n = 20); control group (n = 20)	Pre-intervention versus postintervention	↓of 20.4/14. 2mmHg in SBP/DBP (p<.001/p<.001) after 3 months of intervention and stable BP at reduced levels at the follow-up	42% reduction in medication in treatment group
Patel and North, 1975[152]	Crossover RCT, Phase 1, 6 weeks with 3 months of follow-up; Phase 2, 2 months of washout and 6 weeks of treatment	Hypertensive (n = 34)	Biofeedback--aided yogic relaxation group (n = 17); control group (n = 17)	Pre-intervention versus postintervention and comparison between interventions	↓ of 26.1/ 15.2mmHg in SBP/DBP (p values not provided) in treatment group in phase 1; Difference of 17.8/11 mmHg in SBP/DBP (p<.005/p<.001) between groups in phase 1	↓ of 28.1/154mmHg in SBP/DBP (p values not provided) after two months of washout in control group in phase 2;
Patel and Datey, 1976[154]	NRCT, 9 weeks with 6 months of follow-up	Hypertensive (n = 47)	Biofeedback-aided yogic relaxation group (n = 27); control group, age- and gender-matched: resting on couch (n = 20)	Pre-intervention versus postintervention	↓ of 17.5/13mmHg 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[157]	Cohort, 6 weeks	Medically treated hypertensive (n = 14)	Biofeedback-aided relaxation	Pre-intervention versus postintervention	↓ of 22.7/ 13.4mmHg in SBP/ DBP (p<.001/p<.001), as compared to pre-intervention	↓ of 24.5mg/100ml in serum cholesterol (p<.001); body weight remained stable
Patel and Carruthers, 1977[158]	NRCT, 6 weeks	Hypertensive individuals and in normotensive, smokers, >10 /day (n = 76)	Biofeedback-aided relaxation; hypertensive group (n = 18); smoking group (n = 18); control group (n = 18)	Pre-intervention versus postintervention	↓ of 18.6/11.2mmHg (p<.0005/p<.0005), of 8.2/1.9 (p<01)/nonsignificant and of 9.7/7 mmHg (p<.002/p<.005) in SBP/ DBP for hypertensive, smokers, and normotensive groups, respectively, with yoga	↓ in HR (P<025) and (P<05) in hypertensive group and smoking group, respectively; nonsignificant reduction in body weight in both groups; ↓ in

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
					postintervention, as compared to pre-intervention; no change in control group;	cholesterol and triglyceride levels in hypertensive group; significant reduction in smoking in smoking group
Rappaport and Cammer, 1977[161]	Case Report, one month with 8 months of follow-up)	Hypertensive (n = 1)	Biofeedback relaxation with breath-focused meditation	Pre-intervention versus postintervention	↓ of 35/15mmHg SBP/DBP at follow-up	
Datey, 1980[166]	NRCT, 8 weeks	Hypertensive (n = 20)	Biofeedback and yogic relaxation group (n = 10); control group: resting on couch (n = 10)	Pre-intervention versus 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 weeks with 3 months of follow-up	Hypertensive (n = 21)	Relaxation group: physical relaxation with instructions in weekly session (n = 7); biofeedback group: facilitate relaxation by decreasing physiological arousal in weekly session (n = 8); no-intervention control group (n = 7)	Pre-intervention versus postintervention	↓ of 14.5/12.6mmHg (p<.05/p<.01) and 20.8/14.7mmHg (p<.05/p<.01) in SBP/DBP in relaxation and biofeedback groups, respectively, at the end of follow-up; no change in controls	
Patel, Marmot et al, 1981; Patel, Marmot et al, 1985[155,159]	RCT, Unblinded for 8 months with 4 years of follow-up	Two or more coronary risk factors; (hypertensive, , elevated serum cholesterol or smoking >10/day (n = 204)	Biofeedback-aided relaxation group (n = 99); health-education control group (n = 93)	Pre-intervention versus postintervention	↓ of 15.3/6.8mmHg in SBP/DBP (p<.001/p<.001) after 8 months of follow-up in treatment group; ↓ of 22.4/11.5mmHg in SBP/DBP (p<.001/p<.001) in subgroup of hypertensive group at the end of follow-up	After 4 years of follow-up, reduction in BP was maintained in hypertensive treatment group
Morga, 1986[162]	Cohort, 2 months	Hypertensive (n = 8)	Biofeedback-aided yogic relaxation, 20 sessions	Pre-intervention versus postintervention	↓ of in 24.5/14.3mmHg in SBP/DBP , as compared to pre-intervention (p values not provided)	
Patel and Marmot,	RCT, 8 weeks	Hypertensive (n = 103)	Biofeedback-aided relaxation group (n = 49);	Pre-intervention versus	↓ of 4.9/1.5mmHg in SBP/DBP (p<.0001/p<.015) at the end of one year of	Reduction in cardiovascular events in treatment group

Authors and Year	Design and Duration	Population	Intervention	Comparisons	Blood Pressure (BP) Outcomes	Other Outcomes
1988[156]	with home practice and 12 months of follow-up		no-intervention control group (n = 54)	postintervention	follow-up; no change in controls	
Brownstein and Dembert, 1989[165]	Case report, 6 weeks	Hypertensive (n = 1)	Biofeedback-aided yogic relaxation with incorporation in daily activities of yogic lifestyle techniques.	Pre-intervention versus postintervention	↓ of 16/6mmHg in SBP/DBP after 6 weeks, as compared to pre-intervention; BP remained stable at follow-up	
Latha and Kaliappan, 1991[168]	NRCT, 6 months, 17 sessions	Hypertensive (n = 14)	Yoga group: *asanas, pranayama,* and biofeedback-aided relaxation training (n = 7); no-intervention control group (n = 7)	Pre-intervention versus postintervention	↓of 6.9/5.06mmHg in SBP/DBP (p<.05/ p<.01), as compared to pre-intervention	
Desai, 2001[167]	Cohort, 4 weeks	Hypertensive (n = 20)	Biofeedback-aided yogic relaxation, asana practice with instrumental music	Pre-intervention versus postintervention	↓ of 4.3/9.9mmHg in SBP /DBP (p<.0001/p<.0001), as compared to pre-intervention	
Wang, Li et al, 2010[164]	RCT, one month with follow-up of 1 month and 3 months)	Prehypertensive stage postmenopausal women (n = 26)	Biofeedback-aided relaxation and slow breathing (n = 13); control group (n = 13)	Pre-intervention versus postintervention	↓of 8.4/3.9mmHg in SBP/DBP (p<.001/p<.05) and stable values at follow-up in experimental group; ↓ of 4.3mmHg in SBP (p<.05) but no remarkable effect at follow-up in controls	↑ RR interval (p<.001) during biofeedback; no remarkable change in HRV

Abbreviations: SBP, systolic blood pressure; DB, diastolic blood pressure; NRCT, nonrandomized controlled trial; RCT, randomized controlled trial; HR, heart rate; 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	Blood Pressure (BP) Outcomes	Other Outcomes
Schein, Gavish et al, 2001[174]	Double-blind placebo-controlled RCT, 8 weeks and 6 months 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)	Pre-intervention versus postintervention and comparison between groups	↓ of 15.2/10.5mmHg in SBP/DBP (p<.035/p<.0002) in device group and nonsignificnat reduction in control group, as compared to pre-intervention; postintervention difference between groups in DBP (p<.008)	Stable results of BP in device group at follow-up
Grossman, Grossman et al, 2001[173]	Double-blind placebo-controlled RCT, 8 weeks	Hypertensive (n = 30)	Group using modified breathing with RESPeRATE (n = 15); Control group: listening to music (n = 15)	Pre-intervention versus postintervention and comparison between groups	↓ of 7.5/4mmHg and 2.9/1.5mmHg in SBP/DBP (p values not provided) in active group and control group respectively, as compared to pre-intervention; post intervention difference between groups in SBP/DBP (p<.07/p<.02)	↓ of 8 BPM in HR (p<.05) in active group
Rosenthal, Alter et al, 2001[170]	Cohort, 8 weeks	Hypertensive (n = 13)	Group using modified breathing with RESPeRATE for 15 minutes and self-monitoring BP	Pre-intervention versus postintervention	↓ of 7.2mmHg in SBP (p<.01) in 24-hour ambulatory BP while awake	
Viskoper, Shapira et al, 2003[171]	Cohort, 8 weeks	Hypertensive (n = 17)	Group using modified breathing with RESPeRATE for 15 minutes and self-monitoring BP	Pre-intervention versus postintervention	↓ of 12.9/6.9mmHg in SBP/DBP (p<.001/ p<.001 in clinical settings and ↓ of 6.4/2.6mmHg in SBP/DBP (p<.01/p<.05) in home settings in device group, as compared to pre-intervention	
Elliott, Izzo et al, 2004[175]	Double-blind RCT, 8 weeks	Hypertensive (n = 136)	Group using modified breathing with RESPeRATE for 15 minutes and self-monitoring of BP (n = 79); Control group: self-monitoring of BP (n = 57	Pre-intervention versus postintervn	↓ of 10.6/3.2mmHg in SBP/DBP (p values not provided) in clinical settings in device group, as compared to pre-intervention; ↓ of 8/4.4mmHg in SBP/DBP (p<.005/p<.025) in high users, as compared to low users of device; no statistical difference in controls	
Meles E., 2004[169]	NRCT, 8 weeks	Hypertensive (n = 79)	Group using modified breathing with RESPeRATE for 15 minutes (n = 48), Control group: self-monitoring of blood pressure (n = 31)	Pre-intervention versus postintervention	↓ of 5.4/3.2mmHgin SBP/DBP (p<.001/p<.001) in home BP, as compared to pre-intervention; no significant change in controls	

Elliott and Izzo, 2006[172]	Case report, 8 weeks	Hypertensive with COPD and migraine (n = 1)	Group using modified breathing with RESPeRATE twice daily for 15 minutes and BP monitoring	Pre-intervention versus postintervention	↓ of 17/14mmHg in SBP/DBP (p<.05/p<.001)
Logtenberg, Kleefstra et al, 2007[178]	Single-blind RCT, 8 weeks	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)	Pre-intervention versus postintervention	↓ of 7.8mmHg in SBP p=.008) in device group; ↓ of 12.2mmHgin SBP (p<.001) in control music group, as compared to pre-intervention
Pandic, Ekman et al, 2008[179]	RCT, 16 weeks	Hypertensive (n = 53)	Group using modified breathing with RESPeRATE twice daily for 15 minutes 3 times per week and BP monitoring (n = 31); Control group: random music and BP monitoring (n = 22)	Pre-intervention versus postintervention	↓ of .9/1.5mmHg in SBP/DBP (p<0.12/p<0.001) in device group and ↓ of 16.8/4.1mmHg in SBP/DBP (p<.001/p<.001) in music group, as compared to pre-intervention
Schein, Gavish et al, 2009[176]	RCT, 8 weeks	Hypertensive with type 2 diabetes (n = 66)	Group using modified breathing with RESPeRATE (n = 33); control group: continued with medication unchanged (n = 33)	Pre-intervention versus postintervention	↓ of 10/3.6mmHg in SPB/DBP (p<.001/p<.01) in device group compared to pre-intervention
Altena, Kleefstra et al, 2009[180]	Single-blind RCT, 9 weeks	Hypertensive (n = 30)	Group using modified breathing with RESPeRATE (n = 15); Control group: listening to music and monitoring BP (n = 15)	Comparison between groups	Non-significant postintervention difference in BP between the groups
Anderson, McNeely et al, 2010[177]	RCT, 4 weeks	Hypertensive (n = 40)	Group using modified breathing with RESPeRATE (n = 20); control group: conscious breathing (n = 20)	Pre-intervention versus postintervention	↓ in SBP (p<.029) in treatment group compared to controls in clinic resting

Abbreviations: RCT, randomized controlled trial; SBP, systolic blood pressure; DBP, diastolic blood pressure; BPM, beats per minute; HR, heart rate; NRCT, nonrandomized controlled trial; COPD, chronic obstructive pulmonary disease

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