A Systematic Review and Meta-Analysis of Yoga for Hypertension

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BACKGROUND
The aim of this systematic review and meta-analysis was to evaluate the quality of evidence and the strength of recommendation for yoga as a therapeutic means in the management of prehypertension and hypertension.

METHODS
MEDLINE/Pubmed, Scopus, CENTRAL, and IndMED were screened through February 2014 for randomized controlled trials (RCTs) on the effects of yoga interventions (≥8 weeks) compared with usual care or any active control intervention on blood pressure in patients with prehypertension (120–139/80–89 mm Hg) or hypertension (≥140/≥90 mm Hg). Risk of bias was assessed using the Cochrane risk of bias tool; quality of evidence was assessed according to the GRADE recommendations.

RESULTS
Seven RCTs with a total of 452 patients were included. Compared with usual care, very low–quality evidence was found for effects of yoga on systolic (6 RCTs, n = 278; mean difference (MD) = −9.65 mm Hg, 95% confidence interval (CI) = −17.23 to −2.06, $P = 0.01$; heterogeneity: $I^2 = 90\%$, $\chi^2 = 48.21$, $P < 0.01$) and diastolic blood pressure (6 RCTs, n = 278; MD = −7.22 mm Hg, 95% CI = −12.83 to −1.62, $P = 0.01$; heterogeneity: $I^2 = 92\%$, $\chi^2 = 64.84$, $P < 0.01$). Subgroup analyses revealed effects for RCTs that included hypertensive patients but not for RCTs that included both hypertensive and prehypertensive patients, as well as for RCTs that allowed antihypertensive comedication but not for those that did not. More adverse events occurred during yoga than during usual care. Compared with exercise, no evidence was found for effects of yoga on systolic or diastolic blood pressure.

CONCLUSIONS
Larger studies are required to confirm the emerging but low-quality evidence that yoga may be a useful adjunct intervention in the management of hypertension.

Keywords: blood pressure; hypertension; meta-analysis; review; yoga.

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Hypertension is a major public health problem that was listed as a primary or contributing cause of death in about 348,102 deaths in the United States in 2009.[1] From 1999 to 2009, the death rate from high blood pressure increased 17.1%.[1] Besides pharmacological treatment, lifestyle modification, mainly dietary changes and physical activity, are frequently recommended for all patients with hypertension.[2] Deriving from ancient Indian philosophy, yoga is a complementary medicine system of physical activity and lifestyle modification.[3] In North America and Europe, yoga is most often associated with physical postures, breathing techniques, and meditation, but it often also includes dietary advice.[3] The aim of this systematic review and meta-analysis was to evaluate the quality of available evidence and the strength of recommendation for yoga as a therapeutic means in the management of hypertension.

METHODS

The review was planned and conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines[4] and the recommendations of the Cochrane Collaboration.[5]

Eligibility criteria

Randomized controlled trials (RCTs), randomized crossover studies, and cluster-randomized trials were eligible if they assessed systolic and/or diastolic blood pressure (mm Hg) in adults (aged ≥18 years) with prehypertension (systolic blood pressure 120–139 mm Hg and/or diastolic blood pressure 80–89 mm Hg) or hypertension (systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg).

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Studies comparing any form of yoga (≥ 8weeks) to usual care or any active control intervention were eligible. Studies allowing individual comedication were eligible. No language restrictions were applied.

Search methods

Medline/PubMed, Scopus, the Cochrane Central Register of Controlled Trials (CENTRAL), and IndMED were searched from their inception through 10 February 2014. For PubMed, the complete search strategy was as follows: (Yoga[Mesh] OR yoga[Title/Abstract] OR yogic[Title/Abstract] OR asana[Title/Abstract] OR Pranayama[Title/Abstract] OR Dhyana[Title/Abstract]) AND (Hypertension[Mesh] OR hypertension[Title/Abstract] OR hypertensive[Title/Abstract] OR prehypertension[Title/Abstract] OR Blood Pressure[Mesh] OR blood pressure[Title/Abstract] OR systolic[Title/Abstract] OR diastolic[Title/Abstract]). Reference lists of identified original articles or reviews and the tables of contents of the *International Journal of Yoga Therapy* and the *Journal of Yoga & Physical Therapy* were searched manually.

Data extraction and management

Two review authors independently extracted data on methods (e.g., method of blood pressure assessment), patients (e.g., age, sex, diagnosis, ethnicity), interventions (e.g., yoga type, frequency, and duration), control interventions (e.g., type, frequency, duration), and results using an a priori developed data extraction form. Discrepancies were discussed with a third review author until consensus was reached.

Risk of bias in individual studies

Risk of bias was assessed by 2 authors independently using the Cochrane risk of bias tool.[5] This tool assesses risk of bias using 7 criteria (rating: low, unclear, or high risk of bias): random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. Discrepancies were rechecked with a third reviewer and consensus achieved by discussion.

Data analysis

Assessment of overall effect size. Effects of yoga compared with different control interventions were analyzed separately. If at least 2 studies assessing this specific outcome were available, meta-analyses were conducted using Review Manager 5 software (version 5.1; The Nordic Cochrane Centre, Copenhagen, Denmark) by a random effects model. Mean differences (MDs) between groups and their 95% confidence intervals (CIs) were calculated from means, SDs, and group sizes using the inverse-variance method of meta-analysis.[5] Where no SDs were reported, they were calculated from standard errors, confidence intervals, or *t* values; attempts were made to obtain the missing data from the trial authors by email; or SDs were imputed with the mean SD of the other RCTs. Where appropriate, groups from multiple-arm RCTs (e.g., RCTs comparing different yoga interventions to a single control group) were combined to provide a pooled group estimate; means and SDs were imputed with the weighted mean of the respective group values.[5]

Assessment of heterogeneity. Heterogeneity was analyzed using I^2 statistics and categorized as (i) I^2 = 0%–24%: low heterogeneity; (ii) I^2 = 25%–49%: moderate heterogeneity; I^2 = 50%–74%: substantial heterogeneity; and (iii) I^2 = 75%–100%: considerable heterogeneity.[5,6] The χ^2 test was used to assess whether differences in results are compatible with chance alone; $P \leq 0.10$ was considered to indicate significant heterogeneity.[5]

Subgroup and sensitivity analyses. Subgroup analyses were conducted for (i) type of participants (prehypertension vs. hypertension); (ii) type of yoga interventions (including physical postures vs. not including physical postures); (iii) comedication (allowed vs. not allowed).

To test the robustness of significant results, sensitivity analyses were conducted for studies with high vs. low risk of bias at the domains selection bias, detection bias, and attrition bias. If statistical heterogeneity was present in the respective meta-analysis, subgroup and sensitivity analyses were also used to explore possible reasons for heterogeneity.

Risk of bias across studies. Because <10 studies were included in each meta-analysis, analysis of risk of publication bias was not possible.

Quality of evidence

Based on the methodological quality and the confidence in the results, the quality of evidence for each outcome was assessed according to the GRADE recommendations as high quality, moderate quality, low quality, or very low quality.[7]

RESULTS

Literature search

The literature search yielded 464 nonduplicate records. Four hundred thirty-nine records were excluded because they were not RCTs, participants were not hypertensive, and/or yoga was not an intervention. Out of 25 full-texts assessed for eligibility, 18 were excluded because they were not randomized, not all included patients were diagnosed with (pre)hypertension, they were duplicate publications on the same RCT, a multimodal intervention was used, a single yoga session was used, or blood pressure was not an outcome. Finally, 7 RCTs with a total of 452 patients were included in the analysis (Figure 1).[8–14]

Study characteristics

Of the 7 RCTs, 4 originated from India,[10–14] 2 originated from the United States,[8,9] and 1 originated from Thailand.[11] Patients' mean age ranged 22.5–56.4 years, with a median of 51.3 years; 33.3%–85.0% of participants were women

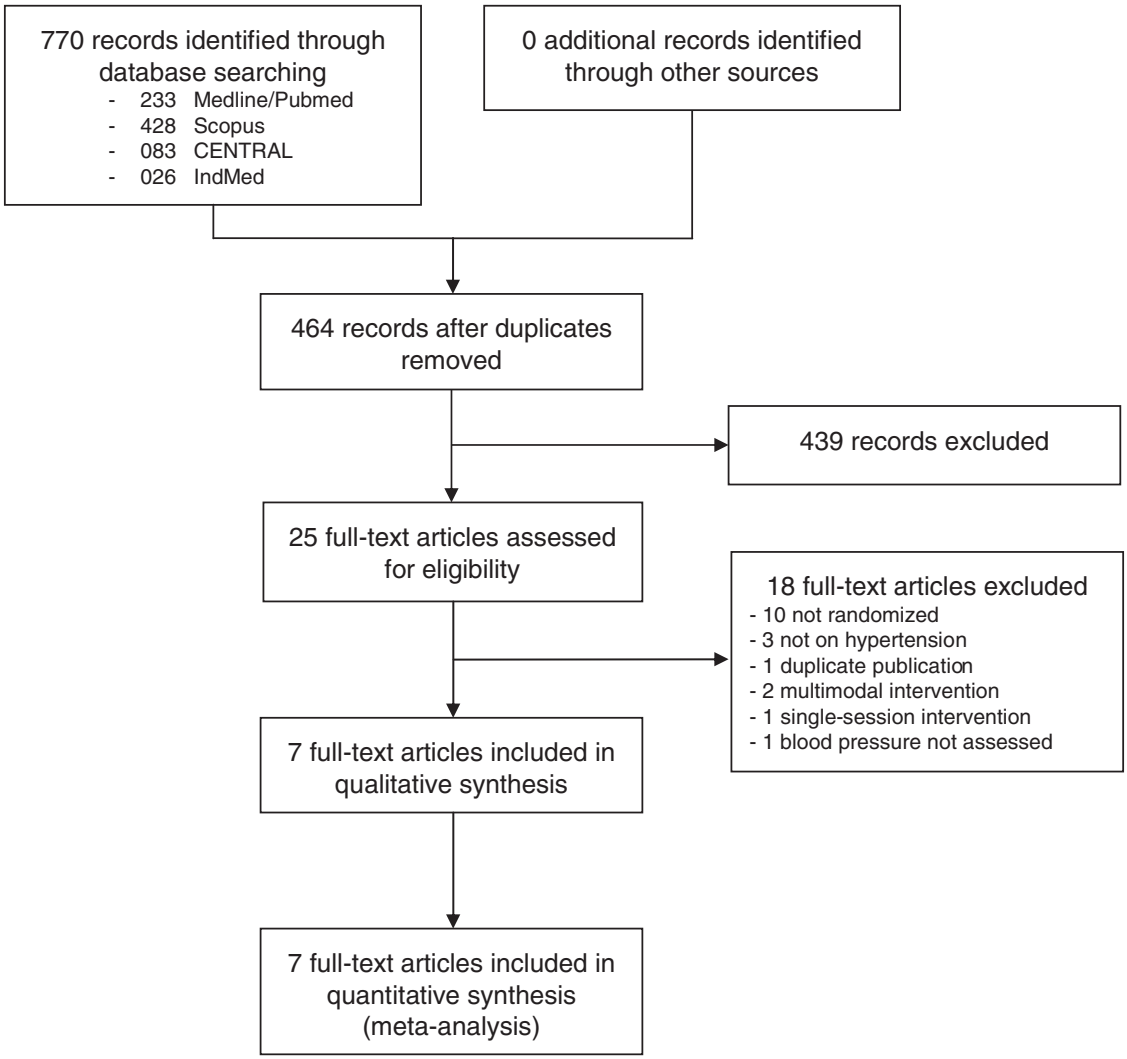

Figure 1. Flowchart of the results of the literature search.

(median = 50.0%); 3.0%–47.4% of patients were white (median = 25.2%).

Only 2 RCTs reported a specific yoga style (Iyengar yoga,[8] Ashtanga yoga[9]). Six RCTs included physical postures in their yoga intervention; these were combined with breathing techniques,[8–11,13,14] relaxation,[10,13,14] meditation,[8,13] and/or lifestyle advice.[11] The remaining RCT used no physical postures but used yoga breathing techniques.[12] Five RCTs compared yoga with usual care or no treatment,[8,10–13] 1 RCT compared yoga with exercise,[9] and 1 RCT compared yoga with usual care, exercise, and diet (Table 1).[14]

Analyses of overall effects

Compared with usual care, very low–quality evidence was found for effects of yoga on systolic (6 RCTs, n = 278; MD = −9.65 mm Hg, 95% CI = −17.23 to −2.06, $P = 0.01$; heterogeneity: $I^2 = 90\%$, $\chi^2 = 48.21$, $P < 0.01$) and diastolic blood pressure (6 RCTs, n = 278; MD = −7.22 mm Hg, 95% CI = −12.83 to −1.62, $P = 0.01$; heterogeneity: $I^2 = 92\%$, $\chi^2 = 64.84$, $P < 0.01$). Compared with exercise, no evidence was found for effects of yoga on systolic or diastolic blood pressure (Supplementary Figure S1). A single RCT compared yoga with low-sodium diet and found no differences between groups.[14]

Two RCTs reported safety data. In 1 RCT, 3 adverse events (not further defined) occurred in the yoga group, and none occurred in the usual care group.[8] In another RCT, no adverse events occurred.[9]

Subgroup and sensitivity analyses

In subgroup analyses, effects were found for (i) RCTs that included hypertensive patients, but not for RCTs that included both hypertensive and prehypertensive patients; (ii) RCTs that did not include physical postures in their yoga interventions, but not for RCTs that included physical postures; and (iii) RCTs that allowed antihypertensive comedication, but not for RCTs that did not allow antihypertensive comedication (Supplementary Table S1). Subgroup analyses could not reduce heterogeneity substantially.

Table 1. Characteristics of included studies

Author, year	Sample size; diagnosis; mean age; gender; ethnicity; baseline blood pressure	Assessment of blood pressure	Treatment group	Control group	Co-medication	Risk of bias						
						RS	AC	BP	BA	IO	SR	OB
Cohen *et al.*[8]	*N* = 78; pre- and stage I hypertension; 48.2 years; 50% female; 47.4% Caucasians; 140.0/86.6 mm Hg	Sphygmomanometer: mean of 3 readings	Iyengar Yoga (P, B); 2 × 70 min/week for 6 weeks + 1 × 70 min/week for 6 weeks	Enhanced usual care; 4 × 60 min/week for 12 weeks	Antihypertensive medication not allowed	U	U	H	H	H	L	L
Hagins *et al.*[9]	*N* = 84; pre- and stage 1 hypertension; 54,5 years; 85% female; 3% Caucasians; 134.7/80.5 mm Hg	24-hour ambulatory blood pressure reading	Modified Ashtanga Yoga (P, B, M); 2 × 55 min/week for 12 weeks + 3 × 20min/week home practice for 12 weeks	Nonaerobic exercise, strengthening, stretching; 2 × 55 min/week for 12 weeks + 3 × 20 min/week home practice for 12 weeks	Antihypertensive medication allowed, no change of dose during the study period	L	L	H	L	U	L	L
Latha *et al.*[10]	*N* = 23; essential hypertension; mean age, gender, and ethnicity not reported; 154.1 /102.5 mm Hg	Sphygmomanometer: 1 reading	Yoga (P, B, R); 17×, twice weekly for 6 months	Usual care over 6 months	Antihypertensive medication allowed	H	H	U	U	H	L	H
McCaffrey *et al.*[11]	*N* = 61; hypertension; 56.4 years; 64.8% female; ethnicity not reported; 160.5/98.4 mm Hg	Not reported	Yoga (P, B, LS); 3 × 63 min/week for 8 weeks	Usual care for 8 weeks	Antihypertensive medication not allowed	L	U	U	U	U	L	U
Mourya *et al.*[12]	*N* = 60; stage 1 hypertension; mean age not reported (range 20-60); 48.3% female; ethnicity not reported; baseline blood pressure not reported	Sphygmomanometer: 1 reading	Yoga (B); 7×/week for 2 weeks + homework 2 × 15 min/day for 3 months	Usual care for 3 months	Antihypertensive medication allowed	L	L	H	L	L	L	L
Murugesan *et al.*[13]	*N* = 33; hypertension; mean age, gender, and ethnicity not reported; 156.8/108.1 mm Hg	Sphygmomanometer: 1 reading	Yoga (P, B, R, M); 6 × 120 min/week for 11 weeks	(1) Usual care for 11 weeks; (2) no treatment for 11 weeks	Not reported	U	U	U	U	U	L	L
Saptharishi *et al.*[14]	*N* = 113; pre- and hypertension; 22.5 years; 33.3% female; ethnicity not reported; 125.5/84.6 mm Hg	Sphygmomanometer: 1 reading	Yoga (P, B, R); 5 × 30–45 min/week for 8 weeks	(1) Usual care for 8 weeks; (2) exercise 4 × 50–60 min/week for 8 weeks; (3) salt intake reduction for 8 weeks	Not reported	L	U	U	U	L	L	L

Abbreviations: AC, allocation concealment; B, breathing exercises; BA, blinding of outcome assessment; BP, blinding of participants and personnel; H, high risk; IO, incomplete outcome data; L, low risk; LS, lifestyle advice; M, meditation; OB, other bias; P, postures; R, relaxation; RS, random sequence generation; SR, selective reporting; U, unclear.

*Cross-over trial with 8 weeks wash out period.

In sensitivity analyses, the effects of yoga compared with usual care on systolic and diastolic blood pressure were robust against selection, detection, and attrition bias.

DISCUSSION

This meta-analysis of 7 RCTs found very low evidence for short-term effects of yoga interventions on systolic and diastolic blood pressure in (pre)hypertensive patients. Systolic and diastolic blood pressure were reduced by 9.65 mm Hg and 7.22 mm Hg, respectively, reflecting large meaningful improvements. Effects were even larger when only patients with hypertension were included; however, no effects were found for prehypertension. Yoga breathing interventions seem to be more effective than those that include physical postures. Yoga was effective as an adjunct intervention to antihypertensive medication but not as an alternative. Yoga seems to be equally effective as conventional exercise or diet. Safety of the intervention was insufficiently reported.

The results of our review are partly in line with those of 3 non-meta-analytic systematic reviews on yoga for patients with hypertension: based on randomized and non-randomized trials published until 2007, Yang found "ample evidence" that yoga was effective in reducing blood pressure.[15] However, the quality of this evidence was not assessed. Okonta's review included 10 randomized controlled trials, quasi-experimental studies, and pilot studies and concluded that yoga can reduce high blood pressure.[16] In contrast, the 2013 American Heart Association scientific statement on alternative approaches to lowering blood pressure concluded that no firm conclusions could be drawn about the antihypertensive effects of yoga.[17] The results are also partly in line with those of 2 recent meta-analyses.[18,19] However, although reaching comparable conclusions, the 2 former meta-analyses can be regarded as less rigid than ours. The review by Hagins *et al.*[18] included studies on patients with metabolic syndrome, who, according to the National Cholesterol Education Program criteria for metabolic syndrome, not necessarily need to be hypertensive. Although claiming to include only RCTs, the review by Wang *et al.*[19] included at least 1 explicitly nonrandomized trial in the meta-analysis.[20] Because the pooled analysis of randomized and nonrandomized trials is generally discouraged,[5] this meta-analysis is difficult to interpret.

The primary limitation of this review is the low number and low methodological quality of the eligible RCTs. Three RCTs included mixed groups of hypertensive and prehypertensive patients, limiting the expressiveness of these trials. Only 1 RCT on yoga breathing intervention was included;[12] thus the interpretation of subgroup analyses for different interventions is limited. Meta-analyses had considerable heterogeneity, and subgroup analyses could not reduce it.

Larger and more rigorous studies are needed to confirm the results of this review. Future RCTs should ensure rigorous methodology and reporting, mainly adequate sample size, adequate randomization, allocation concealment, intention-to treat analysis, and blinding of at least outcome assessors.[21] Future RCTs should put great emphasis on the adequate reporting of safety data. More RCTs are needed that compare yoga to guideline-endorsed interventions such as exercise and/or diet.[17] Because the role of physical postures in the antihypertensive effects of yoga remained unclear, it would be worthwhile to directly compare the effects of different yoga forms.

Although weight and body mass index are related to high blood pressure, based on the included RCT, no clear relationship between weight loss due to yoga and reduced blood pressure could be established. Three RCTs reported changes in weight or body mass index;[8,11,13] 2 reported larger reduction in the yoga groups,[11,13] and 1 reported a reduction in the usual care group only.[8] Associations between weight and blood pressure were not assessed. Future studies should investigate whether weight loss is a mechanism of the antihypertensive effects of yoga.

There is emerging but low-quality evidence that yoga, especially yoga breathing, can be a useful adjunct intervention in the management of hypertension (but not of prehypertension). Patients willing to try yoga should carefully weigh the potential antihypertensive effects found in this review and the potential risks reported in the literature.[22] Given the possibly better risk/benefit ratio, it may be advisable to focus on yogic breathing techniques for hypertension management. Yoga should be considered as an adjunct intervention only and not be regarded as an alternative to antihypertensive medication.

SUPPLEMENTARY MATERIAL

Supplementary materials are available at *American Journal of Hypertension* (http://ajh.oxfordjournals.org).

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DISCLOSURE

The authors declared no conflict of interest.

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