

Blood Pressure Response to Transcendental Meditation: A Meta-analysis

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BACKGROUND

Prior clinical trials suggest that the Transcendental Meditation technique may decrease blood pressure of normotensive and hypertensive individuals but study-quality issues have been raised. This study was designed to assess effects of Transcendental Meditation on blood pressure using objective quality assessments and meta-analyses.

METHODS

PubMed and Cochrane databases through December 2006 and collected publications on Transcendental Meditation were searched. Randomized, controlled trials comparing blood pressure responses to the Transcendental Meditation technique with a control group were evaluated. Primary outcome measures were changes in systolic and diastolic blood pressure after practicing Transcendental Meditation or following control procedures. A specific rating system (0–20 points) was used to evaluate studies and random-effects models were used for meta-analyses.

RESULTS

Nine randomized, controlled trials met eligibility criteria. Study-quality scores ranged from low (score, 7) to high (16) with three studies of high quality (15 or 16) and three of acceptable quality (11 or 12). The random-effects meta-analysis model for systolic and diastolic blood pressure, respectively, indicated that Transcendental Meditation, compared to control, was associated with the following changes: -4.7 mm Hg (95% confidence interval (CI), -7.4 to -1.9 mm Hg) and -3.2 mm Hg (95% CI, -5.4 to -1.3 mm Hg). Subgroup analyses of hypertensive groups and high-quality studies showed similar reductions.

CONCLUSIONS

The regular practice of Transcendental Meditation may have the potential to reduce systolic and diastolic blood pressure by ~ 4.7 and 3.2 mm Hg, respectively. These are clinically meaningful changes.

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Chronic stress may play an important role in initiating and maintaining hypertension for many individuals.¹ Behavioral approaches to reduce chronic stress and lower blood pressure have been evaluated in modern clinical studies for >40 years.² Many clinical trials have examined the effects of cognitive behavioral techniques on blood pressure.³ While a number of randomized clinical trials^{4–10} have evaluated the effects of the Transcendental Meditation technique on blood pressure, the quality and potential bias of these previous studies have been criticized.¹¹ Two recent high-quality randomized controlled trials^{12,13} have evaluated the effects of Transcendental Meditation on blood pressure of hypertensive subjects, but there have been no quantitative meta-analyses of all these studies.

Many agencies and reviewers have proposed rating systems to assess the methodological quality of randomized controlled trials. Recently the Agency for Healthcare Research and

Quality (U.S. Department of Health and Human Services) reviewed 20 scales, 11 checklists, 10 rating systems, and 8 other guidance documents related to randomized controlled trials.¹⁴ They recommended the use of a scale or checklist tailored to the intervention under analysis to include the following elements: study population, randomization, blinding, intervention, outcomes, statistical analyses, and funding or sponsorship. The scale proposed by Jadad and colleagues¹⁵ addressing randomization, blinding, and dropouts has been widely used. A description of the intervention is especially important for non-pharmacological trials,^{3,14} and rigorous attention to blood pressure measurements is essential for hypertension trials.^{3,16}

The objective of this study was to identify randomized controlled trials assessing effects of Transcendental Meditation related to blood pressure, develop an objective assessment for non-pharmacological trials related to blood pressure, and to perform meta-analyses of randomized controlled trials assessing the effects of the Transcendental Meditation program related to blood pressure.

METHODS

Data sources and services. We performed a thorough literature search by using the Cochrane Library and PubMed (National Library of Medicine, Bethesda, MD) through

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31 December 2006 (using combinations of meditation, Transcendental Meditation, blood pressure, and hypertension as search terms) and consulted the reference lists of retrieved articles and review articles. We reviewed the five volumes of Collected Papers on Scientific Research on the Transcendental Meditation Program^{17–19} and >1,600 references provided by Murphy and Donovan.²⁰

Study selection. For analysis, we selected randomized, controlled clinical trials that used Transcendental Meditation as a primary intervention and evaluated blood pressure changes as a primary or secondary outcome measure. We identified 19 full reports of clinical studies related to Transcendental Meditation and hypertension; these studies could be classified as randomized controlled trials suitable for analysis (9),^{4–10,12,13} randomized controlled trials excluded from analysis (3), and observational studies without either randomization or control groups (7).

Data extraction and quality assessment. Based on recommendations from multiple agency and reviewer publications we selected the following 11 elements for evaluation: subject selection,^{14,21} randomization,^{3,15,21} blinding,^{15,21} description of therapeutic intervention,^{3,14} baseline blood pressure assessment after screening visit,^{3,11} description of subjects not completing the study,^{15,21} acceptable subject completion rates,³ appropriate measurements of blood pressure,^{3,11,16,21} data analysis,^{11,14} information on adverse effects,^{22,23} and information on funding or support.^{11,14} These references providing recommendations for assessing randomized controlled trials could be assigned to the following categories: general guidelines,^{14,21,22} hypertension trials,^{11,16} and Transcendental Meditation and blood pressure.^{3,11,23} Following the process delineated by Jadad and colleagues,¹⁵ we assigned scores from 0 to 3 for each element as follows: *subject selection*—0: not defined, 1: defined, 2: no prior Transcendental Meditation experience noted; *randomization*—0: not randomized, 1: randomized, 2: delineated randomization process; *blinding*—0: not blinded, 1: evaluators blinded (double blinding is not possible with Transcendental Meditation studies so no Jadad score of 2 was available); *description of therapeutic intervention* (Transcendental Meditation)—0: not provided, 0.5: limited description, 1: fully described, 2: frequency monitored, 3: weekly meditations averaging >75% of goal (10.5 times/week); *baseline blood pressure assessment after screening visit*—0: not done, 1: done; *description of subjects not completing the study*—0: not provided, 1: detailed; *acceptable subject completion rates*—since there were not specific recommendations we assigned 0 for completion rates of <75% at 12–25 weeks or <50% at 26–52 weeks, completion rates that were better than these criteria were assigned 1; *appropriate measurements of blood pressure*—0: single measurements, 1: multiple measurements, 2: multiple automated measurements, 3: ambulatory blood pressure measurements;^{16,24} *data analysis*—1: appropriate, 2: intention-to-treat analysis, 3: analysis of data in blinded fashion; *information on adverse*

effects—0: not mentioned, 1: mentioned, 2: detailed information provided; and *information on funding or support*—0: not provided, 1: provided. The maximum possible score was 20.

Data synthesis and analysis. Data from studies were extracted and tabulated by first author (J.W.A.) and independently confirmed by second author (C.L.). Two authors (J.W.A., R.J.K.) and a graduate student (Manan Jhaveri, Public Health College, University of Kentucky) independently reviewed studies and assigned quality scores; agreement was achieved by jointly reviewing studies and discussion.

Nine randomized controlled trials that met enrollment criteria were analyzed. Each study had a control group and a Transcendental Meditation treatment group with patients randomly assigned to the groups; comparator treatment groups—Shavasana,⁴ mental relaxation,⁵ mindfulness training,⁵ or progressive muscle relaxation^{6,12}—were not analyzed. Two end points were assessed: mean net changes (treatment minus control) from baseline in systolic and diastolic blood pressure. The standard deviations (s.d.) of mean net changes were not reported for some studies and were calculated as follows: Pearson correlations of s.d. between baseline and follow-up were estimated from studies with complete data after assuming equal variance at baseline and follow-up; this was used to estimate the s.d. of mean net changes for studies with incomplete data, since these studies provided s.d. for baseline and follow-up values. Four studies had blood pressure measurements at multiple follow-up times; in three studies^{4,10,12} changes over time did not differ significantly and mean values for all follow-up values were used. In one study,⁶ the blood pressure changes at 3 months differed significantly from values of 1 and 2 months so the 3-month values were included in the analysis. To examine whether there was a difference between the two groups, for each endpoint, a meta-analysis of these mean differences was performed. Because the clinical designs were heterogeneous, a random-effects model was fitted for each end point as previously described.²⁵ Calculations related to the meta-analyses were done in Number Crunching Statistical System. (J. Hintze, Number Cruncher Statistical Systems, Version 2000, Kaysville, Utah).

RESULTS

Nine randomized controlled trials were suitable for analyses.^{4–10,12,13} Three randomized controlled trials were excluded for the following reasons: one included lifestyle interventions in addition to Transcendental Meditation,²⁶ one did not have a randomized control group,²⁷ and one used a Transcendental Meditation-like procedure that did not include the standard Transcendental Meditation teaching protocol or certified trainer.²⁸ Three abstracts of studies were reported in full publications as follows: Wenneberg *et al.*,⁷ Schneider *et al.*,⁶ and Castillo-Richmond *et al.*,⁸ and one report was a subgroup analysis of the study reported earlier.⁶ Some characteristics of the studies are listed in **Table 1**. All were randomized, controlled, parallel trials, but one⁵ used subjects on a waiting list as controls. Subjects ranged in age

from adolescents to seniors, some were normotensive, some were hypertensive, and some were on antihypertensive medications. Most studies included men and women, but adequate data were not available for subgroup analyses. In the control groups, 344 subjects were enrolled and 76.2% completed the

trial; in the Transcendental Meditation groups, 367 subjects were enrolled and 77.1% completed the trial. Two studies^{4,5} had completion groups of under ten subjects limiting the statistical power of these studies. The duration of studies ranged from 8 to 52 weeks with a median duration of 15 weeks.

Table 1 | Study characteristics

Study	Subject characteristics	No. on Control/TM	Hypertension	Trial	Intervention	Control Group	Weeks	Subjects Control/Intervention	% Male	Age (years)	Completion (%)
Bagga and Gandhi ⁴	Medical students	6/6	No	RCT-P	TM	Relaxation	12	6/6	0	19	100
Alexander <i>et al.</i> ⁵	Elderly retirement home residents	20/11	No	RCT-P	TM	Untreated	13	11/21	17.8	81	81
Schneider <i>et al.</i> ⁶	Older, hypertension	36/38	Yes	RCT-P	TM	HE	13	38/36	41	66	85
Wenneberg <i>et al.</i> ⁷	Healthy men	32/32	No	RCT-P	TM	HE	15	32/32	100	25	63
Castillo-Richmond <i>et al.</i> ⁸	Hypertensive adults	71/67	Yes	RCT-P	TM	HE	29	67/71	31.5	54	44
Barnes <i>et al.</i> ⁹	Adolescents	17/18	High normal	RCT-P	TM	HE	8	18/17	54.5	17	94
Barnes <i>et al.</i> ¹⁰	Adolescents	77/79	High normal	RCT-P	TM	HE	17	77/79	63	16	64
Schneider <i>et al.</i> ¹²	Hypertensive adults	44/54	Yes	RCT-P	TM	HE	52	44/54	48.5	48	69
Paul-Labrador <i>et al.</i> ¹³	CHD	51/52	Yes (62%)	RCT-P	TM	HE	16	51/52	81.5	68	82

CHD, coronary heart disease; HE, health education; RCT-P, Randomized controlled trial-Parallel; TM, Transcendental Meditation.

Table 2 | Rating of clinical trials

Study	Subject selection	Randomization	Single blind	TM (session/week)	Baseline BP evaluation	BP measurements	Dropouts	Completion rates	Analysis	Adverse effects	Funding or support	Sum
Bagga and Gandhi ⁴	1	1	0	1 (nr)	0	1	1	1	1	0	0	7
Alexander <i>et al.</i> ⁵	1	2	1	2 (nr)	0	1	0	1	1	1	1	11
Schneider <i>et al.</i> ⁶	1	2	1	3 (12.9)	1	3	1	1	2	0	1	16
Wenneberg <i>et al.</i> ⁷	1	1	1	2 (8.6)	0	3	1	0	1	0	1	11
Castillo-Richmond <i>et al.</i> ⁸	1	2	1	2 (nr)	2	1	0	0	2	0	1	12
Barnes <i>et al.</i> ⁹	1	1	0	1.5 (10.3)	1	2	1	1	1	0	1	9.5
Barnes <i>et al.</i> ¹⁰	1	1	0	1.5 (9.8)	1	3	1	0	1	0	1	9.5
Schneider <i>et al.</i> ¹²	1	2	1	3 (10.6)	1	2	1	1	2	0	1	15
Paul-Labrador <i>et al.</i> ¹³	2	2	1	3 (~13)	1	1	1	1	1	1	1	15
Maximum Score	2	2	1	3	1	3	1	1	3	2	1	20

nr, not reported; TM, Transcendental Meditation.

Table 3 | Blood pressure values at baseline and completion of trial with changes for control and TM subjects

	Group	Systolic blood pressure			Diastolic blood pressure		
		Baseline mean (s.d.)	Final mean (s.d.)	Change mean (s.d.)	Baseline mean (s.d.)	Final mean (s.d.)	Change mean (s.d.)
Bagga and Gandhi ⁴	Control	119.6 (3.2)	120.0 (3.3)	0.4 (2.7)	78.3 (4.1)	79.3 (2.6)	1.0 (2.8)
	TM	117.6 (7.5)	110.4 (4.9)	-7.3 (5.8)	77.6 (4.1)	73.7 (4.1)	-3.9 (5.2)
Alexander <i>et al.</i> ⁵	Control	NA	135.3	0.0 (12.8)	NA	NA	NA
	TM	NA	125.4	-9.9 (11.5)	NA	NA	NA
Schneider <i>et al.</i> ⁶	Control	150.4 (14.3)	NA	-0.2 (12.3)	91.7 (9.2)	NA	0.8 (9.9)
	TM	145.4 (12.3)	NA	-10.9 (12.6)	93.7 (9.3)	NA	-5.6 (6.6)
Wenneberg <i>et al.</i> ⁷	Control	128.8 (6.2)	NA	-1.3 (8.0)	70.6 (3.8)	NA	0.5 (7.6)
	TM	128.8 (6.7)	NA	1.4 (7.1)	70.6 (4.9)	NA	-4.8 (9.0)
Castillo-Richmond <i>et al.</i> ⁸	Control	149.7 (13.7)	NA	-6.7 (12.8)	87.6 (10.2)	NA	-5.9 (8.6)
	TM	145.5 (13.2)	NA	-7.8 (10.3)	83.4 (9.9)	NA	-3.5 (7.6)
Barnes <i>et al.</i> ⁹	Control	118.8 (8.2)	121.4 (11.2)	2.6 (8.1)	59.7 (5.8)	60.8 (7.9)	1.2 (5.8)
	TM	124.7 (9.1)	119.9 (9.1)	-4.8 (8.3)	61.6 (7.1)	58.1 (8.5)	-3.5 (9.9)
Barnes <i>et al.</i> ¹⁰	Control	130.6 (7.8)	130.5 (8.5)	-0.1 (6.7)	75.8 (5.7)	75.9 (8.1)	0.1 (5.9)
	TM	129.2 (7.8)	125.7 (8.5)	-3.6 (7.5)	75.3 (6.4)	71.7 (8.1)	-3.7 (9.2)
Schneider <i>et al.</i> ¹²	Control	144.4 (17.2)	NA	-0.9 (17.2)	95.7 (3.6)	NA	-2.6 (6.4)
	TM	142.1 (13.5)	NA	-3.1 (13.5)	95.1 (4.1)	NA	-5.7 (6.0)
Paul-Labrador <i>et al.</i> ¹³	Control	127.4 (15.5)	130.5 (16.1)	3.1 (13.1)	76.2 (9.2)	76.5 (9.9)	0.3 (8.0)
	TM	126.4 (14.4)	123.5 (14.9)	-2.9 (13.4)	73.8 (9.7)	73.4 (8.4)	-0.4 (11.5)

NA, not available; TM, Transcendental Meditation.

Rating of studies

The ratings of studies are presented in **Table 2**. All studies provided adequate-to-complete data on subject selection and randomization. Six studies were single blinded with blood pressure measurements performed by personnel blinded to the assignment of subjects. Seven studies indicated that Transcendental Meditation training was provided in a standardized manner by a certified teacher. The two studies of Barnes and colleagues^{9,10} were assigned a score of 0.5 for training, since the training procedure was not well described. One study⁴ did not monitor the frequency of meditations, one⁵ collected this information but did not report it, and one⁸ reported information on class attendance but not on meditation frequency. Two studies reported excellent adherence or >90% to twice daily meditation,^{6,13} one reported very good adherence (>75%) over a 1-year period (10.6), two reported acceptable adherence of >70% (10.3 and 9.8), and one had poor adherence of <70% (8.6).

Three studies did not obtain blood pressure values at multiple visits for baseline assessment after screening measurements (**Table 3**). All studies obtained multiple blood pressure measurements at each visit. Three studies employed ambulatory blood pressure measurements, two used multiple, automated blood pressure measurements, and one used home blood pressure measurements. Two studies did not provide information about subjects who dropped out of the study. Completion rates (**Table 1**) were considered excellent for the top two studies (94–100%) and very good for the next three

studies (81–85%). Because of the 52-week duration, the second study of Schneider and colleagues¹² was considered acceptable. The lowest three studies (the lowest tertile) with completion rates of 43–64% were below our arbitrary criteria for acceptance and received no points in this category. Data analysis was acceptable for all studies, and three studies provided intention-to-treat analyses but none reported that the analyses were done blinded to group assignment.

Only limited information was provided about adverse or side effects (**Table 2**). Two studies provided limited information, and one study⁶ collected this information but did not report it. Alexander and colleagues⁵ reported that subjects who practiced Transcendental Meditation were significantly more relaxed ($P < 0.001$) and less bored ($P < 0.01$) than controls, while Paul-Labrador and colleagues¹³ reported that subjects who practiced Transcendental Meditation had significantly less anger ($P = 0.04$) and that depression and life stressors did not differ from control subjects. Information about funding was provided by eight of the nine studies.

This rating evaluation suggests that three studies were of high quality with scores of 15 (75%) or higher, three were of acceptable quality (scores of >50%), and three were of suboptimal quality (**Table 2**).

Meta-analysis data

For each study and group, the following summaries were developed: baseline blood pressures, mean change scores (follow-up minus baseline), and sample standard deviation

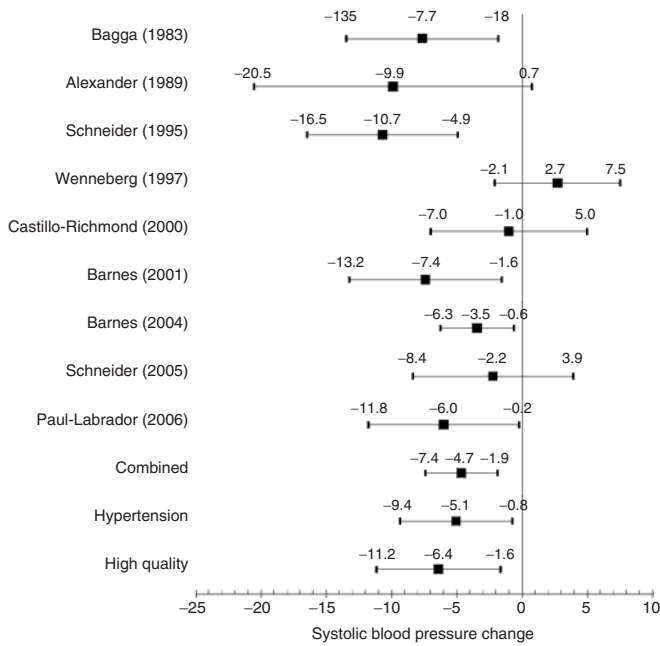


Figure 1 | Systolic blood pressure responses. Values are mean differences (TM minus control) with 95% confidence limits. Combined values for nine studies are presented. Values for four studies of hypertensive subjects^{6,8,12,13} and the three highest quality studies^{6,12,13} are presented.

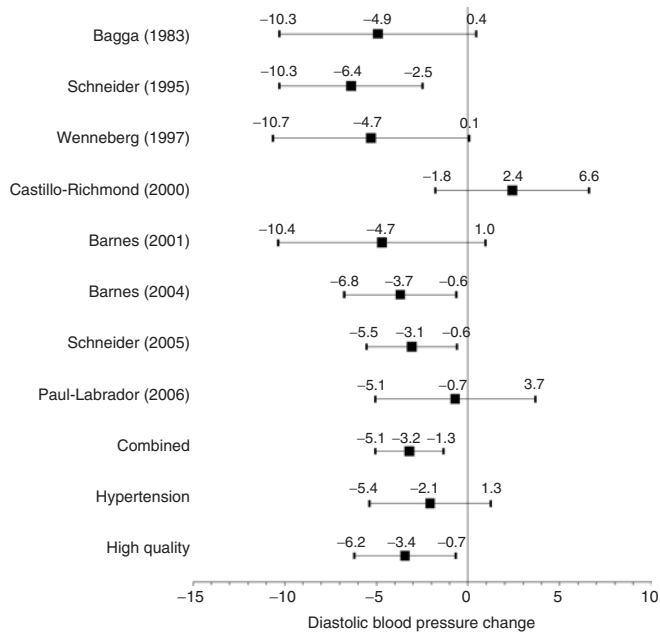


Figure 2 | Diastolic blood pressure responses. Values are mean differences (TM minus control) with 95% confidence limits. Combined values for nine studies are presented. Values for four studies of hypertensive subjects^{6,8,12,13} and the three highest quality studies^{6,12,13} are presented.

of the change score. In addition, estimated mean difference in these two change scores, s.e. and 95% confidence interval (CI) are listed per study. The Cochran's Q value for systolic blood pressure was 16.75 ($P = 0.011$) and for diastolic blood pressure, 12.44 ($P = 0.080$). Because of significant heterogeneity across studies for systolic blood pressure the random-effects

model for meta-analysis was applied. The fixed-effects model yielded mean differences that were very similar to those for the random-effects model (data not shown). The estimated combined mean differences between the groups across all nine reports for systolic blood pressure and eight for diastolic blood pressure, estimated s.e. and 95% CI are presented in **Figures 1 and 2**.

The practice of Transcendental Meditation was associated with significantly greater reductions in systolic and diastolic blood pressures compared to control groups. Eight of nine reports indicate that systolic blood pressure was lower in the Transcendental Meditation group than the control group with an unweighted mean difference of -5.1 mmHg. The variance-weighted mean difference (meta-analysis) in systolic blood pressure for the nine studies was -4.7 (95% CI, -7.4 to -1.9) mm Hg (**Figure 1**). Subgroup analyses of the four studies^{6,8,12,13} that included hypertensive adults were done. The weighted mean difference in systolic blood pressure for these hypertensive subjects was -5.1 (95% CI, -9.4 to -0.8) mmHg. The three studies^{6,12,13} with high-quality scores (15, 15, 16) were also assessed, and the weighted mean difference in systolic blood pressure was -6.4 (95% CI, -11.2 to -1.6) (**Figure 1**).

Seven of eight studies reporting diastolic blood pressure noted a reduction in values in the Transcendental Meditation groups with an unweighted mean difference of -3.3 mmHg. The variance-weighted mean difference in diastolic blood pressure for the eight studies was -3.2 (95% CI, -5.1 to -1.3) mm Hg (**Figure 2**). The weighted mean difference in diastolic blood pressure for the four groups, including hypertensive adults, was -2.1 (95% CI, -5.4 to $+1.3$). The diastolic blood pressure weighted mean difference for three high-quality studies was -3.4 (95% CI, -6.2 to -0.7) (**Figure 2**).

DISCUSSION

The effects of Transcendental Meditation on blood pressure have been addressed in nine randomized controlled trials, and four have evaluated hypertensive adults with three of these studies having high-quality ratings. The studies suggest that Transcendental Meditation is associated with approximate reductions of systolic and diastolic blood pressure of 4.7 mmHg and 3.2 mmHg, respectively. Similar reductions were observed in normotensive and hypertensive individuals. Blood pressure reductions of this magnitude would be expected to be accompanied by significant reductions in risk for atherosclerotic cardiovascular disease.²⁹

Clinical trials using behavioral interventions provide challenges, because appropriate placebos are not available and double blinding is not possible. While subjects cannot be blinded, care can be taken to blind personnel doing assessments and data analyses. Six of the nine trials used single blinding, but none indicated that data analyses were done by individuals blinded to the group assignment. Only three studies used home or ambulatory blood pressure monitoring—a widely recommended procedure.¹⁶ Three studies had average sample sizes of <20 for groups completing the trial suggesting

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that they were underpowered to detect blood pressure changes of the expected magnitude.

Prior studies of Transcendental Meditation and blood pressure have been criticized because of the quality of the trials,^{11,23} potential side effects of Transcendental Meditation,²³ and potential bias of investigators.^{11,23} Our assessment suggests that at least three trials related to Transcendental Meditation and blood pressure have been of high quality. The anecdotal reports of adverse psychological effects³⁰ or increased seizures³⁰ have not been documented in randomized controlled trials. Two of the randomized controlled trials in this review^{5,13} indicated that psychological function was improved with Transcendental Meditation, while another study⁶ collected information but did not mention differences in side effects between groups. Rigorous analyses of available data suggest that Transcendental Meditation tends to decrease anxiety and have other psychological benefits.^{31–33} Further analyses are required to assess these effects.

Probably all investigators bring bias to implementation of clinical trials—either enthusiasm or skepticism.³⁴ Our early hypothesis that oat bran would effectively lower serum cholesterol values was supported by an enthusiastic team and volunteers who were eager to participate.³⁵ The “oatbran craze” was ended by a skeptical team using dietitians as volunteers.³⁶ Clinical trials related to lifestyle may be performed more skillfully by experienced experts in the field—such as exercise, nutrition, or behavioral specialists. Instead of criticizing the credentials, interests or affiliation of the investigative team, it may be more appropriate to rigorously assess the quality of the trial and expect that any bias will be minimized by the following measures: provision of suitable information to potential subjects, appropriate screening and selection of subjects, use of a rigorous randomization process, skilled training of subjects about the intervention, state-of-the-art measurements of outcome variables, blinding in data collection and analysis, diligent collection of adverse event information, and full disclosure of any potential conflicts of interest.^{11,37,38}

In conclusion, most of the randomized clinical trials examining the effects of Transcendental Meditation on blood pressure suggest that this practice lowers blood pressure. A random-effects meta-analysis of nine trials suggests that Transcendental Meditation is associated with a significant reduction in systolic and diastolic blood pressure of ~5 and 3 mm Hg, respectively. Sustained blood pressure reductions of this magnitude are likely to significantly reduce risk for cardiovascular disease.

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