Feature Article/Online Only

Effects of Transcendental Meditation on Blood Pressure

A Meta-analysis

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The authors have no funding or conflicts of interest to disclose.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.jcnjournal.com).

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The Journal of Cardiovascular Nursing: 5/6 2022 - Volume 37 - Issue 3 - p E11-E21
doi: 10.1097/JCN.0000000000000849

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Metrics

Abstract

Hypertension is a worldwide public health issue. The World Health Organization estimates that 1.13 billion people worldwide have hypertension, up from 594 million in 1975. The increase was largely seen in low- and middle-income countries where two-thirds of those with hypertension reside.[1] One of the global targets for 2025 is to reduce the prevalence of hypertension by 25%.[1] In the United States, 45% of adults had hypertension in 2017 to 2018, and the prevalence increases with age.[2]

To reduce hypertension and its related consequences (coronary artery disease, stroke, heart failure, and renal failure), healthcare leaders made several recommendations. These include eating a diet with less than 5-g salt daily, eating more fruits and vegetables, limiting foods high in saturated fats and eliminating trans fats, engaging in regular physical activity, avoiding the use of tobacco, and reducing alcohol consumption. In addition, people with hypertension should seek treatment for their blood pressure and other medical conditions, and reduce and manage mental stress.[1] Although pharmaceutical management of both blood pressure and stress are available, there are several reasons why people prefer not to take medications. Among them are costs, adverse effects, and, in some cases, lack of access. Thus, there is a need for alternative nonpharmacological healthy lifestyle methods. One of those methods is meditation.

Meditation is becoming popular in the United States. Although there are several types of meditation, transcendental meditation (TM) is one of the most studied types of meditation,[3] in particular with regard to its effect on blood pressure. The purpose of this study was to quantitatively synthesize the effects of TM on blood pressure. In addition, we examined the moderator effects of participant, methodological, and intervention characteristics on these effects.

Several meta-analyses similar to this one have been conducted for the past 15 years with several limitations.[4–10] Although 1 meta-analysis team searched 17 databases,[6] overall analysts searched 7 or fewer databases. All meta-analysis teams included only randomized trials to compute the effects of TM on blood pressure. Several meta-analysts used quality rating scales and did moderator analyses using quality scores. Others included primary studies on adolescents with primary studies on adults.

In this current meta-analysis, we addressed these limitations. We searched 9 electronic databases and 10 journal databases. Because we believe that quasi-experimental designs more closely reflect real life, we included studies with quasi-experimental designs in our effect size computations. In addition, because we had a larger number of primary studies than previous meta-analyses, we conducted moderator analyses on participant, intervention, and methodological characteristics. To address quality, we coded quality indicators and used moderator analyses to examine their influence on effect size.[11] Finally, given that adulthood is the time when blood pressures begin to vary, we included primary studies of adults only. Thus, this meta-analysis is more comprehensive than previous meta-analyses of the effects of TM on blood pressure in adults.

Methods

We followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines in reporting the aspects of this study.[12]

Search Strategy

We searched 19 electronic databases without date restrictions to March 2021 including gray literature and specific journals. Electronic databases and their inception dates included Education Resources Information Center (1966+), CINAHL (1937+), Scopus (1788+), Ovid PsycINFO (1967+), Ovid Medline (1946+), Cochrane Library (1995+), Bielefeld Academic Search Engine (2004+), ProQuest Dissertation & Theses (1996+), ClinicalTrials.gov (2000+), American Journal of Hypertension (1988+), The American Journal of Cardiology (1958+), European Society of Hypertension (1983+), Journal of American Society of Hypertension (2007+), International Journal of Hypertension (2009+), Journal of Human Hypertension (1987+), Journal of the American Heart Association (2012+), Journal Mindfulness-Springer link of the American Heart Association (2010+), ScienceDirect (1995+), and American Psychological Association (1892+). In addition, we searched reference lists of all relevant articles, as well as previous reviews and meta-analyses, for eligible studies (ancestry search).

Search Terms

We generated search terms and consulted with a librarian with specific expertise in systematic reviews. Search terms included "pulmonary wedge pressure" OR "blood pressure" OR "arterial pressure" OR "venous pressure" OR hypertension OR hypertensive OR "portal pressure" AND meditat* OR mindfulness OR mindful* OR meditation. Truncating these terms with an asterisk allowed for related terms. We exploded subject headings. Our intention was to cast a broad net to capture all studies with meditation (not only TM) and blood pressure.

Inclusion/Exclusion Criteria

We included primary studies in which the researchers claimed to use TM interventions to reduce blood pressure in adults with a mean age of 18 years or older and written in English. Unpublished dissertations were also included. We excluded studies testing other meditation interventions. We included primary studies where systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) were measured as a quantitative outcome. We included research designs with comparison groups including attention control (which included rest, relaxation, or health education), no treatment, or waitlist control groups (ie, randomized controlled trials and quasi-experimental designs). We excluded qualitative studies and studies with fewer than 3 participants per group. We excluded systematic reviews and meta-analyses except to use them for ancestry searches. Finally, we excluded studies where the researchers did not report sufficient data to compute the mean difference. All inclusion/exclusion decisions were based on the consensus between the first 2 authors.

Data Extraction and Coding

After we reviewed all 18 primary studies, we refined the codebook and pilot tested it with 5 studies. We coded primary studies for 5 categories including source, method, intervention, participant characteristics, and outcome information. For source, we coded publication status, year, funding, and country. We coded methodological characteristics that mainly reflected quality indicators, namely, type of comparison group (eg, control vs health education, relaxation, or rest, each of which might affect blood pressure), sampling strategy (eg, random, stratified random, convenience), group assignments (eg, random, stratified random, nonrandom, cluster), concealed allocation, masked data collectors, intention-to-treat analysis, a priori power calculation, comparison of participant characteristics at baseline, intervention fidelity, and setting. Participant characteristics included the number of participants at baseline and at analysis (to compute attrition, a quality indicator), mean age, gender breakdown, racial/ethnic breakdown, and the presence of clinical health conditions (eg, overweight, diabetes, cardiovascular disease, hypertension, asthma, high cholesterol, cancer, anxiety, and major depressive disorder). Coded intervention characteristics included interventionists' discipline and whether they were trained and certified. For both structured and unstructured aspects of TM, we coded length in weeks, number of sessions per week, duration in minutes, and format (individual, group, online). We also coded components of the intervention (eg, eyes closed, guided meditation, music, mantra, and health education). Finally, outcome data included baseline and follow-up SBP and/or DBP mean values and SDs, sample size at analysis, and the direction of the effect.

For missing data critical to the computation of the mean difference, we emailed primary authors for the data. When we received no reply after 2 emails, we excluded the primary study from this meta-analysis. When researchers published multiple studies with the same participants, we coded only 1 study so we would not duplicate participants and artificially inflate our sample size. In addition, when research teams provided interventions that included multiple components or had more than 2 groups, we compared the TM group with like comparison groups without TM to examine the effects of TM only.

The first 2 authors independently coded primary studies and compared codes for discrepancies. Differences in coding were discussed until a consensus was reached. There were a total of 18 studies (s = 18), which provided 18 comparisons (k = 18). Finally, we double-entered data into RedCap, downloaded into SPSS, and compared for entry errors. Once data entry errors were corrected, we used SPSS for descriptive statistics and Comprehensive Meta-Analysis (CMA v.3) for meta-analysis.

Statistical Analyses

We examined study characteristics using descriptive statistics. Because blood pressures were reported on a known metric (mm Hg), we computed the raw mean difference between TM and control groups at postintervention follow-up with 95% a confidence interval.[13] We used a random-effects model because we assumed that effects are normally distributed across studies and that studies are heterogeneous with regard to participants and methods.[13] With the random-effects model, CMA weights each study by the inverse of the within- and between-study variance to estimate the summary mean difference.[13]

To examine the possibility of spontaneous reduction in blood pressure over time in the case of control group or the effects of health education, rest, or relaxation in the case of the comparison groups, we computed single-group pre/post mean differences in blood pressure within each of the TM and control groups.[13,14] If we found a blood pressure reduction in the control/comparison groups similar to a reduction in TM groups, we would suspect that TM is no more effective than any conventional intervention or spontaneous recovery. Because within-group analysis requires correlations that are typically not reported, we ran the analysis estimating no correlation (r = 0.0) and reanalyzed estimating correlation (r = 0.8).

We examined heterogeneity across studies by visually inspecting the forest plot and by computing the Q statistic reflecting total dispersion (weighted sum of squares). A significant Q indicates heterogeneity across studies. In addition, we examined the I^2 statistic as a ratio of variability reflecting the proportion of observed dispersion that is due to the heterogeneity. We categorized an I^2 statistic of 25%, 50%, and 75% as low, moderate, and high heterogeneity, respectively. An I^2 statistic near 100% means most the observed variance is true variance.[13] For example, an I^2 of 70% across studies would indicate that the variance of the mean difference across studies was 70% and variance due to sampling error was 30%. In other words, I^2 is the proportion index providing information about the extent of inconsistency of findings across studies in meta-analysis.[15]

When heterogeneity existed, we conducted exploratory moderator analyses by comparing the mean blood pressure differences across subgroups to determine the effects of various study characteristics (source, methods, participants, and intervention). A meta-analytic analog of ANOVA was used to test categorical moderators; meta-regression was used for continuous moderators.[13]

Assessment of Study Quality

Given the limitations of study quality instruments, we considered quality to be an empirical question and we conducted moderator analyses for each of the quality indicators.[11] That is, we examined the effects of each quality indicator (eg, concealed allocation, group assignment [random vs nonrandom], blinded data collector, a priori power calculation, type of comparison group, intention-to-treat analysis, comparison of participants' characteristics at baseline, intervention fidelity, and attrition rate) on effect size. Quality indicators are depicted in Supplemental Digital Content, Table 1, https://links.lww.com/JCN/A142.

Risk of Publication Bias

To estimate publication bias, we visually inspected the funnel plot for symmetry. The funnel plot displays the difference in means against the standard error. Asymmetry suggests publication bias. We also used the Begg and Mazumdar rank correlation test and the Egger regression test. The Begg and Mazumdar test provides the rank order correlation (Kendall τ) between the treatment effect and variances (standard error, which is primarily affected by sample size). If this test shows significant results ($P < .05$, 1-tailed), it suggests publication bias. In addition, a significant 1-tailed Egger regression test suggests publication bias.[13,14]

Results

Initial and updated electronic database searches resulted in 7378 studies after duplicates were removed. We added 7 ancestry studies, resulting in 7385 studies. With review of the titles and abstracts, we excluded 7118 studies. Of the remaining 51 studies (*s*), 33 were excluded for the following reasons: systematic review or meta-analyses (*s* = 18), insufficient data for computing effect size (*s* = 7), letters/opinion papers (*s* = 6), not written in English (*s* = 1), and case study (*s* = 1). Finally, a total of 18 studies met inclusion criteria[16–33] and were included in this meta-analysis (see Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram: Figure 1).

F1
FIGURE 1:
Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow of studies included in meta-analysis.

Description of Primary Studies

The 18 primary studies (*s* = 18) that met inclusion criteria provided 18 between-group comparisons (*k* = 18). Ten of 18 studies were funded. All studies were published between 1978 and 2015. Sixteen studies were conducted in the United States, and one each was conducted in India and Israel. A total of 1207 participants were included: 623 in TM groups and 584 in control groups. Sample mean age ranged from 24.2 to 74.7 years, with a total mean (SD) age across studies of 51.1 (14.2) years (*s* = 16). Of those participants, 604 (50%) were female across studies. Most participants across studies (*s* = 14) were reported as of Black (54%) or White (34%) race. Attrition rates ranged from 0% to 40.4%, with a mean of 12.4% across studies (*s* = 14; see Tables 1 and 2). Finally, across the studies, baseline SBP for the TM groups was 130.9 ± 12.7 mm Hg with a DBP of 81.2 ± 7.2 mm Hg; baseline SBP and DBP for the comparison groups were 130.8 ± 13.6 and 81.3 ± 7.6 mm Hg, respectively.

TABLE 1 - Descriptive Data of Included Primary Studies (*S* = 18)

Authors (Year), Country	Age, Mean (SD), y	Female/Total N	Participants	Method	TM/Control (n)	Intervention to BP Outcome, d
Abrams & Siegel (1978), United States	—	0/40	Prisoners	Quasi	26/14	91
Bagga & Gandhi (1983), India	—	12/12	Medical students	RCT	6/6	84
Barnes et al (1999), United States	46.4 (3.9)	16/32	Healthy adults	Quasi	18/14	0
Broome et al (2005), United States	36.0 (—)	27/31	—	RCT	24/7	167.8
Calderon (2000), United States	53.9 (10.05)	47/71	Hypertensive AA	RCT	35/36	183
Castillo-Richmond et al (2000), United States	53.9 (10.1)	41/40	Hypertensive AA	RCT	31/29	207.4
Cooper & Aygen (1978), Israel	43.1 (8.7)	19/44	Meditators	Quasi	23/21	305
De Armond (1996), United States	43.1 (8)	17/75	Adults	Quasi	38/37	91.5
Duraimani et al (2015), United States	58.1 (10.5)	26/48	Patients with hypertension	RCT	24/24	112
Fields et al (2002), United States	74.7 (7.4)	5/9	Older adults	RCT	6/3	366
Kondwani et al (2005), United States	50.7 (8.74)	19/34	AA, hypertensive heart disease	RCT	19/15	366
Nidich et al (2009), United States	25.8 (9.59)	122/207	University students	RCT	93/114	91.5
Paul-Labrador et al (2006), United States	67.4 (9.8)	15/84	Patients with CAD	RCT	45/39	112
Schneider et al (1995), United States	65.6 (7.5)	44/74	AA with hypertension	RCT	36/38	91.5
Schneider et al (2005), United States	48.5 (10.1)	50/98	AA with hypertension	RCT	54/44	366
Schneider et al (2012), United States	59.1 (10.6)	85/183	AA with CAD	RCT	86/97	1976.4
Toomey (2007), United States	64.6 (6.3)	30/48	Native Hawaiians	RCT	25/23	274.5
Wenneberg et al (1997), United States	24.6 (—)	0/39	Normotensive men	RCT	21/18	122

Abbreviations: AA, African Americans; BP, blood pressure; CAD, coronary artery disease; Quasi, quasi-experimental; RCT, randomized controlled trials; TM, transcendental meditation.

TABLE 2 - Demographic and Study Characteristics Across Studies
Scroll left or right to view entire table.

Characteristics	*s*	Min	Q1	Mdn	Q3	Max	Mean	SD
Mean age, y	16	24.2	43.1	52.3	63.2	74.7	51.1	14.2
Total sample size analyzed	18	9.0	33.5	48.0	77.3	207.0	67.1	55.2
TM group	18	6.0	20.5	25.5	39.8	99.0	34.6	25.4
Control group	18	3.0	14.0	23.5	38.3	114.0	32.4	30.1
% Female	18	0	37.4	55.7	66.7	100.0	51.4	27.3
% African American	14	0	2.0	62.5	100.0	100.0	53.6	48.6
% White	14	0	0	0	77.9	100.0	34.4	42.6
Days of structured TM	15	1.0	4.0	5.0	6.0	6.0	4.5	1.4
No. structured TM sessions as planned	15	1.0	5.0	13.0	18.0	76.0	15.9	17.9
Duration, min/session	15	69.0	81.8	90.0	90.0	105.0	88.6	10.5
Days after TM intervention measured	18	0	91.5	144.9	320.3	1976.4	278.2	438.5
% of attrition	14	0	0	12.8	21.0	40.4	12.4	12.7
% of attrition, TM group	14	0	0	8.7	17.5	41.5	11.2	13.0
% of attrition, control group	14	0	0	6.2	26.6	44.0	13.0	15.6
Total quality indicator scores	15	1.0	3.0	4.0	5.0	6.0	3.7	1.5

Abbreviations: Max, maximum; Mdn, median; Min, minimum; Q1, first quartile; Q3, third quartile; *s*, number of studies; TM, transcendental meditation.

Effects of Transcendental Meditation on Blood Pressure

Figure 2 displays the forest plot of each primary study's effect size as well as the summary effect size. The size of each square reflects the study's weight and influence on the summary mean difference. Weights reflect precision, which are largely driven by sample size. Studies with good precision are assigned greater weight (and more influence) than studies with less precision. The width of the line shows the confidence intervals of each effect size. The diamond below the studies shows the overall, or summary, mean difference with the width of the diamond reflecting the confidence interval for the summary mean difference. Thus, across all 18 comparisons, TM mildly improved SBP by −3.3 mm Hg (P = .025; see Figure 2) and DBP by −1.8 mm Hg (P = .008; see Figure 3) compared with controls. Four primary studies had a significant reduction of SBP; and 5 primary studies, for DBP (P < .05).

F2
FIGURE 2:
Forest plot of the effects of transcendental meditation (TM) on systolic blood pressure compared with control groups.
F3
FIGURE 3:
Forest plot of the effects of transcendental meditation (TM) on diastolic blood pressure compared with control groups.

TM group pre-post comparisons showed that SBP improved by an mean difference of −3.99 mm Hg (P < .000) when groups were uncorrelated groups (r = 0.0) and of −4.01 mm Hg (P < .000) when groups were correlated (r = 0.8). Control group pre-post comparisons showed no difference in SBP when groups were uncorrelated (−1.52, P = .230) or when correlated (−1.76, P = .175). These findings suggest that the effects we see in SBP were likely not the result of spontaneous change (see Table 3). However, we saw a different pattern in single-group pre-post comparisons of DBP. For the TM groups, the uncorrelated and correlated pre-post analyses resulted in −3.10 and −3.33, respectively, which are both significant (P < .000). Similarly for the control groups, the uncorrelated and correlated pre-post analyses resulted in −1.94 and −1.98, respectively, which are also both significant (P < .01). Thus, although the mean difference in DBP reduction was greater for the TM group, the control groups had a significant reduction indicating that at least part of the TM effect was related to spontaneous recovery (see Table 3).

TABLE 3 - Random-Effects Model of Transcendental Meditation Intervention on Blood Pressure
Scroll left or right to view entire table.

Comparison	***k***	**MD**	***P*(MD)**	**95% CI**	**SE**	***Q***	***P*(*Q*)**	***I*²**
Systolic blood pressure								
TM group, pre vs post (r = 0.0)	18	−3.99	<.000	−5.66 to −2.33	0.85	25.35	.087	32.9
TM group, pre vs post (r = 0.8)	18	−4.01	<.000	−5.60 to −2.42	0.81	114.99	<.000	85.2
Comparison, pre vs post (r = 0.0)	18	−1.76	.175	−4.31 to 0.78	1.30	49.93	<.000	66.0
Comparison, pre vs post (r = 0.8)	18	−1.52	.230	−4.01 to 0.96	1.27	248.72	<.000	93.2
Diastolic blood pressure								
TM group, pre vs post (r = 0.0)	18	−3.10	<.000	−4.35 to −1.84	0.64	46.55	<.000	63.5
TM group, pre vs post (r = 0.8)	18	−3.33	<.000	−4.47 to −2.18	0.58	225.53	<.000	92.5
Comparison, pre vs post (r = 0.0)	18	−1.94	.009	−3.40 to −0.48	0.75	60.73	<.000	72.0
Comparison, pre vs post (r = 0.8)	18	−1.98	.003	−3.29 to −0.66	0.67	280.89	<.000	93.9

Abbreviations: CI, confidence interval; I^2, heterogeneity; k, number of comparisons; MD, mean difference; Q, total dispersion; TM, transcendental meditation.

Publication Bias

For SBP, the funnel plot seemed relatively symmetrical (see Supplemental Digital Content, Figure 1, https://links.lww.com/JCN/A143). Egger test of the intercept was −0.07 (P = .956, 2-tailed), and Begg and Mazumdar rank correlation test resulted in a Kendall τ of 0.07 (P = .677, 2-tailed). Likewise, for DBP, the funnel plot seemed relatively symmetrical except for 1 point reflecting a considerable increase in DBP with a high standard error (see Supplemental Digital Content, Figure 2, https://links.lww.com/JCN/A144). Egger test of the intercept was −0.66 (P = .324, 2-tailed). Begg and Mazumdar rank correlation test reflected a nonsignificant Kendall τ of 0.06 (P = .733, 2-tailed). Thus, findings suggest that publication bias is unlikely.

Moderator Analyses' Results

Heterogeneity statistics for SBP (Q = 71.6, P = .000, I^2 = 76.2) and DBP (Q = 51.9, P = .000, I^2 = 67.2) suggested considerable heterogeneity and supported moderator analyses. Moderator analyses showed that, when blood pressure was measured less than 3 months after the intervention, SBP dropped by −8.00 mm Hg; when measured more than 3 months after the intervention, the SBP dropped by only −0.69 mm Hg (see Table 4). Because Bai and colleagues[8] categorized age as older than and younger than 65 years as a moderator, we computed a similar moderator analysis. We categorized age to be 65.49 years or younger, or older than 65.50 years. We found that TM reduced SBP in the older category significantly more than the younger category (−9.87 vs −1.44, P = .021) but showed no differential effect on DBP. None of the categorical moderators made a significant effect on DBP (see Table 5), and none of the continuous moderators significantly influenced the effects of TM on blood pressure (see Tables 6 and 7).

TABLE 4 - The Effects of Transcendental Meditation on Systolic Blood Pressure Across Categorical Moderators
Scroll left or right to view entire table.

Moderator	***k***	**MD**	**SE**	**Variance**	**95% CI**	***Z***	***P*(*Z*)**	***Q* bet**	***P*(*Q* bet)**
Source									
Funding								0.47	.492
Unfunded	8	−2.01	2.45	5.99	−6.80 to 2.79	−0.82	.412		
Funded	10	−4.17	1.97	3.89	−8.03 to −0.31	−2.12	.034		
Method									
Setting								0.78	.377
Clinical/health center	4	−1.18	2.82	7.98	−6.72 to 4.36	−0.42	.676		
Community	13	−4.08	1.67	2.77	−7.34 to −0.81	−2.45	.014		

Moderator	k	MD	SE	Variance	95% CI	Z	P(Z)	Q bet	P(Q bet)
Assignment into groups								0.58	.445
Nonrandomization	4	−5.52	3.21	10.29	−11.80 to 0.77	−1.72	.085		
Randomization	14	−2.76	1.66	2.76	−6.01 to 0.50	−1.66	.097		
Concealed allocation (randomized studies only)								0.01	.917
No	5	−2.46	3.00	9.01	−8.34 to 3.42	−0.82	.412		
Yes	9	−2.85	2.21	4.90	−7.19 to 1.49	−1.29	.198		
Masked								2.09	.148
No	5	−6.42	2.49	6.21	−11.31 to −1.54	−2.58	.010		
Yes	13	−2.13	1.62	2.61	−5.30 to −1.04	−1.32	.188		
Type of comparison group								0.06	.801
Control	6	−2.71	2.81	7.87	−8.20 to 2.79	−0.97	.34		
Rest or education	11	−3.56	1.92	3.68	−7.33 to 0.20	−1.86	.06		
Intention-to-treat								0.18	.672
No	13	−2.92	1.80	3.24	−6.45 to 0.61	−1.62	.105		
Yes	5	−4.35	2.86	8.20	−9.96 to 1.26	−1.52	.129		
Participants' characteristics equal across groups								0.06	.813
No	8	−2.89	1.95	3.81	−6.71 to 0.94	−1.48	.140		
Yes	8	−2.17	2.31	5.35	−6.71 to 2.36	−0.94	.348		
SBP measured after intervention								9.52	.002
At 3 mo or less	6	−8.00	1.86	3.46	−11.65 to −4.36	−4.30	<.001		
At more than 3 mo	12	−0.69	1.47	2.16	−3.57 to 2.20	−0.47	.640		
Participants' characteristics									
Hypertensive diagnosis								0.02	.896
No/unable to determine	11	−3.49	1.89	3.55	−7.18 to 0.21	−1.85	.064		
Yes	7	−3.08	2.45	6.01	−7.89 to 1.73	−1.26	.209		
Age categories, y								5.30	.021
≤65.49	13	−1.44	1.40	1.95	−4.18 to 1.29	−1.03	.301		
≥65.50	3	−9.87	3.38	11.45	−16.51 to −3.24	−2.92	.004		
Overweight								2.56	.110
No/unable to determine	8	−5.79	1.98	3.92	−9.66 to −1.91	−2.93	.003		
Yes	10	−1.57	1.75	3.06	−5.00 to 1.86	−0.90	.370		

Abbreviations: CI, confidence interval; I^2, proportion of observed variance across mean difference due to true differences in effects; *k*, number of comparisons; MD, mean difference; *Q*, conventional homogeneity statistic; SBP, systolic blood pressure.

TABLE 5 - The Effects of Transcendental Meditation on Diastolic Blood Pressure Across Categorical Moderators
Scroll left or right to view entire table.

Moderator	k	ES	SE	Variance	95% CI	Z	P(Z)	Q bet	P(Q bet)
Source									
Funding								0.28	.595
Unfunded	8	−1.30	1.17	1.36	−3.58 to 0.99	−1.11	.266		
Funded	10	−2.08	0.89	0.79	−3.83 to −0.33	−2.33	.020		
Method									
Setting								2.26	.133
Clinic/health center/primary care	4	−0.34	1.14	1.31	−2.58 to 1.90	−0.30	.765		
Community	13	−2.38	0.72	0.52	−3.79 to −0.96	−3.28	.001		
Assignment into groups								0.08	.776
Nonrandomization	4	−2.19	1.58	2.48	−5.28 to 0.90	−1.39	.164		
Randomization	14	−1.69	0.79	0.63	−3.25 to −0.13	−2.13	.033		
Concealed allocation (randomized studies only)								0.08	.781
No	5	−1.95	1.27	1.61	−4.44 to 0.54	−1.54	.124		
Yes	9	−1.50	1.05	1.10	−3.55 to 0.56	−1.43	.154		
Masked								0.49	.484
No	5	−2.58	1.31	1.72	−5.15 to −0.01	−1.97	.049		
Yes	13	−1.50	0.80	0.64	−3.07 to 0.07	−1.87	.061		
Type of comparison group								0.40	.525
Control	6	−2.44	1.16	1.34	−4.71 to −0.17	−2.11	.04		
Rest or education	11	−1.55	0.80	0.63	−3.11 to 0.01	−1.95	.05		
Intention-to-treat								0.00	.978
No	13	−1.78	0.87	0.76	−3.49 to −0.06	−2.03	.042		
Yes	5	−1.82	1.26	1.59	−4.29 to 0.66	−1.44	.150		
Participants' characteristics equal across groups								0.29	.591
No	8	−1.12	0.77	0.59	−2.63 to 0.39	−1.46	.145		
Yes	8	−1.78	0.95	0.91	−3.65 to 0.09	−1.87	.062		
DBP measured after intervention								2.53	.112
At 3 mo or less	6	−3.14	1.07	1.14	−5.23 to −1.05	−2.95	.003		
At more than 3 mo	12	−1.00	0.82	.82	−2.61 to 0.61	−1.22	.223		
Participants' characteristics									
Hypertension diagnosis								2.26	.133

Moderator	k	ES	SE	Variance	95% CI	Z	$P(Z)$	Q_{bet}	$P(Q_{bet})$
No/unable to determine	11	−2.48	0.73	0.54	−3.92 to −1.05	−3.39	.001		
Yes	7	−0.70	0.93	0.86	−2.53 to 1.12	−0.76	.450		
Age categories, y								1.33	.250
≤65.49	13	−1.12	0.66	0.43	−2.40 to 0.17	−1.71	.088		
≥65.50	3	−3.32	1.82	3.23	−6.85 to 0.20	−1.85	.065		
Overweight								2.36	.125
No/unable to determine	8	−3.08	1.06	1.13	−5.17 to 1.00	−2.90	.004		
Yes	10	−1.01	0.83	0.69	−2.64 to 0.62	−1.21	.226		

Abbreviations: CI, confidence interval; DBP, diastolic blood pressure; ES, effect size; I^2, proportion of observed variance across mean difference due to true differences in effects; k, number of comparisons; MD, mean difference; Q, conventional homogeneity statistic.

TABLE 6 - The Effects of Transcendental Meditation on Systolic Blood Pressure Across Continuous Moderators

Moderator	k	Slope	SE	τ^2	Q_{model}	P
Sample characteristics						
Age (mean)	16	−0.13	0.11	24.23	1.24	.266
% Female	18	−0.06	0.06	24.33	1.07	.301
% White	14	−0.01	0.04	22.85	0.04	.834
% African American	14	−0.01	0.03	24.31	0.04	.848
Method characteristics						
% Attrition	14	0.11	0.11	35.49	0.99	.320
Quality of study	15	0.86	1.07	23.30	0.64	.424
Intervention characteristics						
Days across TM training, n	15	0.41	1.01	20.59	0.17	.680
Structured TM session, n	15	0.01	0.08	24.52	0.02	.902
Duration of each structured TM session, min	12	−0.06	0.16	19.93	0.13	.720
Days after TM training and blood pressure was measured	18	0.00	0.00	28.90	0.10	.752

Abbreviations: k, number of comparisons; Slope, meta-regression coefficient (unstandardized); TM, transcendental meditation.

TABLE 7 - The Effects of Transcendental Meditation on Diastolic Blood Pressure Across Continuous Moderators

Moderator	k	Slope	SE	τ^2	Q_{model}	P
Sample characteristics						
Age (mean)	16	0.03	0.05	2.33	0.47	.491
% Female	18	−0.03	0.03	3.16	1.26	.261
% White	14	−0.01	0.02	2.93	0.59	.443
% African American	14	0.00	0.01	3.10	0.10	.748
Method characteristics						
% Attrition	14	0.03	0.05	5.85	0.25	.620
Quality of study	15	0.32	0.51	4.09	0.40	.528
Intervention characteristics						
Days across structured TM training, n	15	0.04	0.44	3.24	0.01	.922
Structured TM session, n	15	0.03	0.04	2.72	0.58	.446
Duration of each structured TM session, min	12	−0.06	0.07	2.5	0.70	.404
Days after TM training and blood pressure was measured	18	0.001	0.002	4.54	0.27	.603

Abbreviations: k, number of comparisons; Slope, meta-regression coefficient (unstandardized); TM, transcendental meditation.

Discussion

Overall, we found that TM mildly improved SBP (−3.3 mm Hg) and DBP (−1.8 mm Hg) compared with control/comparison groups, although some of the improvement in DBP may have been from spontaneous change or conventional treatments (education, resting, or relaxation exercises). Previous meta-analytic effect sizes for SBP ranged from −1.1 to −5.6 mm Hg, and those for DBP ranged from −0.6 to −4.3. Across the 18 studies included in our meta-analysis, we noted considerable variability in effect sizes (Figures 2 and 3). Across the effect sizes for SBP (Figure 2), 4 primary studies showed significant effect sizes.[17,18,28,30] For DBP (Figure 3), 5 primary studies resulted in significant effect sizes.[17,22,27,29,30]

Our work constitutes the most comprehensive meta-analysis on this topic thus far. Of the 18 primary studies, 14 were randomized trials, whereas previous meta-analysts included 5 to 12. Unlike others, we also computed the effects of 4 quasi-experimental studies.[16,18,22,23] Although Gathright et al[7] reported retrieving quasi-experimental studies for their meta-analysis, they did not include the quasi-experimental studies in their effect size analyses. We then compared effect sizes across randomized and nonrandomized studies and found no differences (Tables 4 and 5).

Our moderator analyses resulted in 2 subgroup differences. We found that SBP measured within 3 months (s = 6) of the TM intervention (training) dropped impressively more than when measured after 3 months (s = 12) from the intervention (−8.0 vs −.69, respectively, P = .002; Table 6). Others found similar trends.[6,8] One explanation for these findings may be that participants were relatively engaged in meditating for the first 3 months after TM training, after which their practice waned. Future researchers might examine the relationship between TM dose and blood pressure at several intervals for 1 or more years. Diastolic blood pressure showed similar trends, but these trends were not significant (Table 5).

Another moderator, categorical age, also showed differences. Across the primary studies, researchers who studied participants who were older than 65 years (s = 3) showed a much greater reduction in SBP than researchers who studied participants who were 65 years or younger (s = 13; −9.9 vs −1.4, respectively; P = .021). Others found similar results.[4,8] In contrast, Gathright et al[7] found age not to be a moderator, but it is not clear whether they treated age as a categorical or continuous variable. When we used age as a continuous moderator, it was not significant (Tables 6 and 7). One explanation for these categorical age findings might be that blood pressure tends to increase with age.[34,35] Another explanation might be that older adults may have greater motivation to reduce their reliance on medications[4] and they likely have more time to incorporate meditation into their schedules. With only 3 studies with samples older than 65 years, future researchers might consider examining the effects of TM in various older age groups, for example, 64- to 72-year-olds and 73-year-olds and older.

Interestingly, Bai et al[8] showed that women had a considerable drop in SBP after TM than men. We did not find the proportion of women to be a moderator similar to Gathright and colleagues'[7] findings. Future researchers might explore the gender differences on the TM effects on blood pressure.

From a practice standpoint, the effects of TM in this study (−3.3 mm Hg systolic and −1.8 mm Hg diastolic) are unlikely to replace medication for many. In fact, some people, perhaps many, might prefer to take medication instead of incorporating a healthy lifestyle into their schedule. However, combined with dietary and physical activity, TM complements other lifestyle modifications to further reduce blood pressure. Future researchers might examine the effects of various health behaviors, to include TM, on medication changes. Transcendental meditation along with complementary lifestyle changes may be most effective as a preventive measure for those who are prehypertensive.[4] Future researchers might also examine the additive effects of diverse health behaviors, including TM, on blood pressure.

This meta-analysis has several strengths. First, we included nonrandomized trials in our analysis because we believe they reflect real life. As expected, nonrandomized trials had higher effect sizes than randomized trials, but the differences were not significant. Second, we used quality indicators as moderators to examine the difference in effect sizes based on whether each indicator was reported. Third, we included more studies than any other similar meta-analysis even without counting the nonrandomized trials. Thus, this meta-analysis updates and extends earlier ones.

There are also several limitations. First, we included only studies written in English. There may be additional studies in non-English journals that would have met our inclusion criteria. Second, we may have missed some studies despite our diligent search, and we know that 7 studies would likely have qualified if the researchers could have been reached or would have responded to provide their blood pressure data. Third, because of our small sample of primary studies, our moderator analyses had smaller group sizes, which increases the risk of both false-positive and false-negative findings. We recommend interpreting these moderator analysis findings with caution and using them for exploratory hypothesis generating as opposed to hypothesis testing.[36]

In conclusion, TM mildly reduced blood pressure, but the effect waned after 3 months. Adults older than 65 years benefited more than those younger than 65 years. Transcendental meditation might be recommended as one aspect of a comprehensive healthy lifestyle.

What's New and Important

- Transcendental meditation improved SBP by −3.3 mm Hg and DBP by −1.8 mm Hg.
- Transcendental meditation was most effective when measured less than 3 months after training compared with more than 3 months after training.
- Transcendental meditation reduced SBP in samples that were 65 years and older significantly more than in samples that were younger than 65 years but showed no differential effect on DBP.
- Transcendental meditation effects are unlikely to replace medication, but with other lifestyle modification (dietary and physical activity), it may further improve blood pressure.

Acknowledgment

The authors thank Mary Krieger for her assistance with the comprehensive literature search.

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Keywords:
blood pressure; complementary therapies; hypertension; meditation; meta-analysis

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