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Original Article

Effects of the Transcendental Meditation Technique on Trait Anxiety: A Meta-Analysis of Randomized Controlled Trials

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Abstract

Objective: This meta-analysis of randomized controlled trials (RCTs) on the Transcendental Meditation® (TM) technique updates previous meta-analyses and assesses the effects of initial anxiety level, age, duration of practice, regularity of practice, research quality, author affiliation, and type of control group on effect sizes.
Design: This systematic review of the literature used the Comprehensive Meta-Analysis (CMA) program for core analyses of effect sizes, bias analysis, meta-regression, and moderator variable analysis. Comprehensive literature searches included databases devoted to meditation research.
Results: More than 600 TM research papers were identified; 14 of these addressed trait anxiety and reported on 16 studies among 1295 participants with diverse demographic characteristics. No adverse effects were reported. The standardized difference in mean, d, for the TM technique compared with controls receiving an active alternative treatment (10 studies) was $d = -0.50$ (95% CI, $-.70$ to -0.30; $p = 0.0000005$). Compared with controls receiving treatment as usual (wait list or attention controls, 16 studies), $d = -0.62$ (95% CI, -0.82 to -0.43; $p = 1.37\text{E-}10$). Meta-regression found that initial anxiety level, but not other variables, predicted the magnitude of reduction in anxiety ($p = 0.00001$). Populations with elevated initial anxiety levels in the 80th to 100th percentile range (e.g., patients with chronic anxiety, veterans with post-traumatic stress disorder, prison inmates) showed larger effects sizes (-0.74 to -1.2), with anxiety levels reduced to the 53rd to 62nd percentile range. Studies using repeated measures showed substantial reductions in the first 2 weeks and sustained effects at 3 years.
Conclusion: Overall, TM practice is more effective than treatment as usual and most alternative treatments, with greatest effects observed in individuals with high anxiety. More research is needed in this area, especially with high-anxiety patients, conducted under medically supervised conditions.

Introduction

Anxiety disorders are the most common mental health problem in the United States, affecting 40 million adults (about 18% of the population) and costing more than $42 billion a year.[1,2] Anxiety is considered a negative mood disturbance that results from failure to predict, control, and obtain desired goals[3] and is associated with dysfunctional cognition, behavior, and physiologic overactivity.[4] Anxiety further impairs health by motivating increased use of tobacco and alcohol[5] and predisposes the individual to chronic diseases such as coronary heart disease.[4,5]

Different traditions prescribe the use of meditation to increase focus, equanimity, and global integration as a means of overcoming the disintegrating and weakening effects of anxiety.[6] Travis and Shear have classified three types of meditation according to their electroencephalographic (EEG) signatures,[7] and each is potentially beneficial for treating anxiety. Focused-attention meditation, corresponding to gamma (20–50 Hz) EEG waves, has as its goal improving the ability to focus attention during activity, which would be advantageous in dealing with threat. Open monitoring (mindfulness) techniques produce theta (4–8 Hz) EEG waves and are intended to cultivate a nonjudgmental attitude toward moderate anxiety-producing interpretations of experience. Automatic self-transcending (e.g., the Transcendental Meditation® [TM] technique) entails the effortless use of a sound without meaning (mantra), which allows the mind to settle to quieter levels of thought until it achieves the silent state of transcendental consciousness, a process called "transcending."[8] Transcending is physiologically the opposite of anxiety (e.g., reduced respiratory rate, skin resistance,

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plasma lactate, and cortisol).[9–13] It increases alpha EEG coherence and synchrony,[14–16] which provide long-range integration of distal cortical-neural groups necessary for sensory, motor, and cognitive behavior.[17,18] EEG alpha coherence is inversely correlated with state and trait anxiety[14] and positively correlated with self-esteem, creativity, flexibility of concept learning, and moral reasoning,[14,19–21] all important capabilities for increasing resilience and overcoming anxiety.

Two meta-analyses found that the TM technique was more effective than other meditation and relaxation techniques for reducing trait anxiety.[22,23] A third study[24] found that all meditation techniques produce similar effects, but it did not include randomized controlled trials (RCTs) on the TM technique that were identified as early as 1989[22] or others published since then. Therefore, the first goal of the present meta-analysis was to locate and analyze all the randomized studies on the effects of TM practice on trait anxiety. The second goal was to study the effects of initial anxiety level on effect sizes because a prior meta-analysis found that patients with elevated pretest anxiety showed larger effects than those without elevated anxiety.[25] The third goal was to study the effects of age, duration of practice, regularity of practice, researcher affiliation, and CLEAR score (a checklist of research quality)[26] on effect sizes.

Methods

Literature search

Major databases (PubMed, Cochrane Collaboration, Dissertation Abstracts International), meditation bibliographies, review papers, and research anthologies[27–30] were searched for papers on the TM technique and trait anxiety from 1970 to 2012. Authors who had conducted randomized studies on the TM technique were also directly contacted. A total of 696 research papers and reviews on the TM technique were identified; 14 papers reported on 16 RCTs on the effects of the TM technique on trait anxiety.

Study eligibility

The inclusion criteria for studies used in this meta-analysis were that the study (1) reported the results of the standard TM technique[8] as a treatment; (2) used one or more control or comparison groups;* (3) randomly assigned participants to experimental and control groups; (4) reported longitudinal change over time; and (5) reported outcomes for trait anxiety.

Data coding

Full copies of the 14 qualified papers were obtained and their statistical data, including age, gender, duration of the treatment, regularity of practice, and type of anxiety test used, were extracted, entered into the Comprehensive Meta-Analysis Program (CMA)[31] and a table, and checked by a proofreader. Study quality was assessed by using the CLEAR score check list.[26] We were able to contact all but one author for study details on such areas as randomization procedures, allocation concealment, and assessor blinding. Pretest anxiety scores in percentiles were calculated for each study group relative to norms for working adults, which was set at the 50th percentile.†

The test-retest reliabilities of the anxiety tests for different populations at different test-retest intervals (which are needed to calculate the effect sizes) were taken from test manuals, principally the STAI manual, Table 11 (page 30).[32]

Data analysis

We used the CMA program[31] for the core analysis, bias analysis, and meta-regression. This program includes pretest–posttest correlations in its calculations of effect sizes, taking into account the influence of test reliability on the effect sizes. The random-effects model[33] was used because of the wide differences between study populations on initial levels of anxiety, age, and other variables. The core analysis included the point estimate of the standard difference in the means, d (standardized by the post-treatment standard deviation), its standard error, variance, 95% confidence interval (CI), Z score, statistical significance, and Forest plots. Heterogeneity was assessed by using the Q statistic and its associated p-value, and the I^2.‡

Potential publication bias was assessed by inspection of funnel diagrams, and their asymmetries were quantitated by the Begg and Mazumdar rank correlation and Egger regression intercept tests.[33] The Rosenthal classic fail-safe N was used to calculate how many missing nonsignificant studies it would take to reduce the mean effect size to nonsignificance.[34] The Orwin fail-safe N was used to calculate how many missing studies would be needed to reduce the effect size to a trivial level, defined as $d = -0.1$. The Duval and Tweedie trim and fit method was used to assess the potential impact of missing studies on the observed mean effect size.

Meta-regression was used to assess the effects of potential moderator variables, initial anxiety level, age, duration of the study, regularity of TM practice, and CLEAR score using the random-effects model (mixed effects regression, methods of moments).[33] The proportion of variance explained by the covariate in a meta-regression is an analogue to the familiar R^2 used in primary regression analyses.§

*A comparison group is an alternative active treatment for anxiety that the TM technique was compared with, whereas control groups control for treatment as usual and/or nonspecific features of the research setting, such as attention and expectation.

†A supplemental materials spreadsheet is available from the first author, which has all the computational details for this meta-analysis.

‡I^2 indexes heterogeneity by giving the proportion of the observed variance that is real between-studies variance, as opposed to variance due to sampling error of a common underlying effect (fixed effect).

§In meta-regression, R^2 is not the proportion of total variance as it is in primary regression analysis but rather the proportion of the between-study variance, given by I^2, where T^2_{total} (tau-squared total) is the between-studies variance from the core analysis without the covariate, and $T^2_{\text{unexplained}}$ is the between-study variance remaining after the meta-regression has been performed. For example, if $I^2 = .90$, indicating that 90% of the variance in the meta-analysis is between-study variance (heterogeneity), and $R^2 = .6$, it would mean that 60% of the 90% heterogeneity is explained by the covariate.[33]

Table 1. Summary Characteristics of Randomized Controlled Trials on the Transcendental Meditation Technique and Anxiety

Study, year	Population	Anxiety measure	Initial anxiety (percentile)		Patients, (% male)	Age (y)	Duration (wk)	Type of control	CLEAR score	Notes on control groups
			TM	Control						
Ballou, 1977[35]	Prison inmates	STAI	83	84 WL 87 NI	59 (100)	25	11	WL NI	0.75	Wait list/delayed start No interest in TM
Barnes, et al., 2003[36]	High school students	BASC-2PRS	73	73	63 (71)	17	16	ATT	0.67	Health education classes on reducing cardiovascular risk factors Intervention parallel to TM
Brautigam, 1972[37]	Drug rehabilitation clients	PA-radet	86	86	20 (70)	20	26	AA	0.19[a]	Group therapy, 4 times/week client-centered with minimal therapist control
Brooks and Scarano, 1985[38]	Veterans with PTSD	TMAS	95	98	18 (100)	25	12	AA	1.00	Psychotherapy, weekly individual, eclectic approaches, option for group or family therapy
Dillbeck, 1977[39]	College students	STAI	71	40	33 (79)	22	2	AA	0.77	Simple relaxation, sitting with eyes closed in the same posture and schedule as TM
Gaylord et al., 1989[40]	College students	STAI	71	71	83 (47)	21	52	AA ATT	0.73	Progressive muscle relaxation (Jacobson, 1982)[49] Classes on various topics on self-Improvement. Intervention structured parallel to TM
Gore et al., 1984[41] #1	Prison inmates	PAF	86	86	42 (100)	23	2	AA	0.85	Relaxation: sitting quietly, conversing, watching educational videotapes Intervention structured parallel to TM
Gore et al., 1984[41] #2[b]	Prisoner inmates	PAF	86		49 (100)	23	18	PP	NA	Pretest–posttest of random sample of inmates
Gore et al., 1984[41] #3[b]	Prison staff	PAF	86	86	18 (100)	45	16	PP	NA	Pretest–posttest of random sample of prison staff
Kondwani et al., 2003[42]	Hypertensive patients	MHI	41	41	34 (44)	52	52	ATT	0.87	Health education classes on reducing cardiovascular risk factors Intervention structured parallel to TM
Nidich et al., 2009[43]	College students	POMS	68	67	207 (41)	25	12	WL	0.83	WL /delayed start
Paul-Labrador et al., 2006[44]	Patients with coronary heart disease	STAI	48	63	103 (82)	68	16	ATT	0.86	Health education classes on reducing cardiovascular risk factors Intervention structured parallel to TM
Raskin et al., 1980[45]	Volunteers diagnosed with anxiety neurosis	TMAS	100	100	31 (26)	35	12	AA AA	0.56[c]	Progressive relaxation tapes EMG frontalis biofeedback during practice of progressive relaxation, schedule matched to progressive relaxation group
Sheppard et al., 1997[46]	High-security government agency staff	STAI	64	62	32 (85)	51	12	AA	0.80	Corporate stress management practices (deep breathing, muscle relaxation, self-awareness exercises) Instruction time matched to TM

(continued)

Table 1. (Continued)

Study, year	Population	Anxiety measure	Initial anxiety (percentile)		Patients, (% male)	Age (y)	Duration (wk)	Type of control	CLEAR score	Notes on control groups
			TM	Control						
Smith, 1976,[47] #1	High-anxiety college students	STAI	90	95 WL 92 PSI	78 (50)	22	24	AA WL	0.91	Periodic somatic inactivity involving twice-daily sitting, with expectation fostering features matched to TM WL controls told they could learn in 3 mo
Smith, 1976,[47] #2[d]	High-anxiety college students	STAI	89	97	54 (50)	22	11	AA AA	NA	CMS1 was a TM-like mantra meditation CMS2 involved focus on positive thoughts
So and Orme-Johnson, 2001,[48] #1	High school students	STAI	73	73	154 (51)	17	26	AA NI	0.91	Napping, involving naps on the same daily schedule as TM No interest in TM
So and Orme-Johnson, 2001,[48] #2	High school students	STAI	75	75	118 (0)	15	26	WL AA	0.91	No treatment wait list Tao: meditation on the meaning of Tao (not randomized)
So and Orme-Johnson, 2001,[48] #3	High school students	STAI	72	72	99 (100)	18	52	WL	0.91	No treatment, wait list

[a]Unable to contact the author in Sweden of this study published in 1972.
[b]These uncontrolled pretest–posttest studies by Gore et al. were not included in the meta-analysis of randomized, controlled trials.
[c]Author did not remember details of the study, which was published in 1980.
[d]This second study by Smith (1976) was not on the TM technique and was included only in the analysis of the independent effects of AA treatments, not in the comparisons with the TM technique.

AA, alternative active; ATT, attention control; BASC-2PRS, Behavior Assessment System for Children-Second Edition, Parent Rating Scales; CLEAR, a checklist of research quality; CMS, cortically mediated stabilization; EMG, electromyography; MHI, Mental Health Inventory, NA, not applicable; NI, no interest; PA-radet, test by a major Swedish consulting firm; PAF, Paranoid Anxiety Factor, a factor score loading on the STAI and the Guilt, Suspicion, and Resentment scales of the Buss-Durkee Hostility Inventory (see Gore et al., 1984 for details); POMS, Profile of Moods States; PTSD, post-traumatic stress disorder; STAI, State-Trait Anxiety Inventory; TM, Transcendental Meditation; TMAS, Taylor Manifest Anxiety Inventory; WL, wait list.

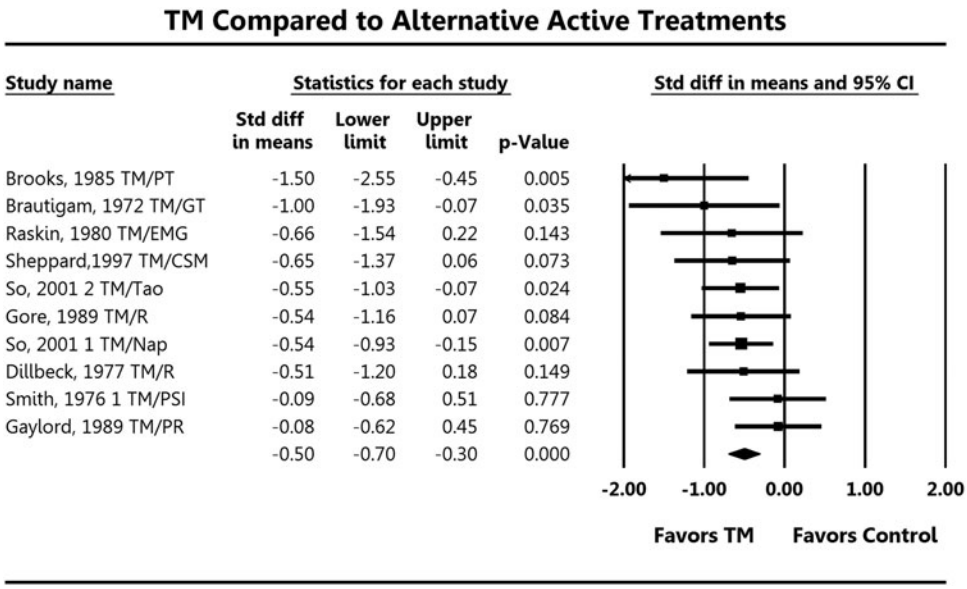

FIG. 1. Forest plot of 10 studies on Transcendental Meditation (TM) compared with active alternative treatments: psychotherapy (PT), group therapy (GT), electromyography biofeedback with progressive relaxation (EMG), simple relaxation (R), napping (Nap), corporate stress management (CSM), a Taoist meditation technique (Tao), periodic somatic inactivity (PSI), and progressive relaxation (PR). CI, confidence interval.

To study researcher affiliation, the studies were partitioned into two groups, MUM (Maharishi University of Management**) and other universities.[††] The statistical significance of the difference between summary effect sizes between two groups of studies A and B, was tested by $Z_{diff} = \frac{Diff}{SE_{diff}} = \frac{M_B - M_A}{\sqrt{V_{M_A} + V_{M_B}}}$ where M_A and M_B are the means of groups A and B, and V_A and V_B are their respective variances. The p for Z_{diff} was calculated in Excel® (Microsoft, Redmond, Washington) by $2\times(1 - \text{NORMSDIST}(Z_{\text{diff}})$.[33] For all tests, nonsignificance was defined at $p>0.05$, two tailed.

Results

Characteristics of the included studies

Fourteen papers reporting on 16 RCTs on the effects of the TM technique on trait anxiety were identified.[35–48] Table 1 shows the wide diversity of the study populations in terms of initial anxiety level, age, research design, and other factors.

TM technique compared with alternative active treatments

Figure 1 shows the results for the 10 studies that compared the TM technique with alternative active treatments.[‡‡]

Overall, the TM technique compared with alternative active controls had an effect size of $d=-0.50$ (95% CI, $-.70$ to -0.30; $p=0.0000005$). No alternative active treatment produced a greater effect than the TM technique. Heterogeneity was not significant, $Q(9)=9.3$ ($p=0.41$) and $I^2=2.87$, indicating that only 2.87% of the variance was due to heterogeneity. The classic fail-safe N was 65, which exceeded the Rosenthal criterion[§§] for a robust effect,[34] and the Orwin fail-safe N was 40. The Egger regression intercept was not statistically significant, indicating an absence of publication bias in the funnel plot.

Independent effects of alternative active treatments

Figure 2 shows that the overall summary effect size for all alternative active treatments*** was small ($d=-0.29$ [95%

**MUM was formerly known as Maharishi International University. The MUM category also includes Maharishi European Research University and Maharishi Vedic University. MUM_1 = all studies for which any of the authors or coauthors listed on the publication were from MUM: $other_1$ = all other studies. MUM_2 = all studies that met the above criteria, plus papers published *only* in *Scientific Research on the Transcendental Meditation Program*, volumes 1–7;[27–30] $Other_2$ = all other studies; $MUM_3 = MUM_2$ plus studies for which the authors had any affiliation with MUM at any time, before or after they published their papers (e.g., as a student or faculty); $Other_3$ = all other studies.

††Other universities were Graduate Department of Social Anthropology University of Kansas,[35] Institute of Public and Preventive Health, Georgia Regents University,[36] Department of Psychology, University of Lund, Sweden,[37] Denver Vietnam Veterans Outreach Program,[38] Purdue University,[39] Department of Social and Behavioral Sciences, University of Arkansas, Pine Bluff,[40] Institute of Social Rehabilitation, Burlington, Vermont,[41] Morehouse School of Medicine, Atlanta, Georgia,[42] Psychology Department, American University,[43] Department of Medicine, Cedars-Sinai Research Institution,[44] Department of Psychiatry, University of California, San Francisco,[45] West Oakland Health Center and Haight-Ashbury Drug Rehabilitation Center,[46] Department of Psychology, Roosevelt University.[47]

‡‡There were two alternative active treatment comparisons along with the TM technique in the Raskin (1980)[45] study: progressive muscle relaxation and progressive relaxation plus electromyography biofeedback. The current analysis compared TM with the electromyography group because the study authors considered it to be the more powerful treatment, and it included the progressive muscle relaxation component. The independent effects of both electromyography and progressive muscle relaxation are estimated in the section on effects of alternative active treatments.

§§The Rosenthal criteria for a robust effect is for the fail-safe N (number of studies) to exceed $5N+10$, which is 60 for the 10 studies comparing the TM technique with alternative active controls.

***To assess the independent effects of the active alternative treatments, a meta-analysis was performed for alternative active treatments on pretest/posttest changes for 11 of the outcomes and on treatment-as-usual controlled outcomes for the two studies in which treatment-as-usual controls were available.

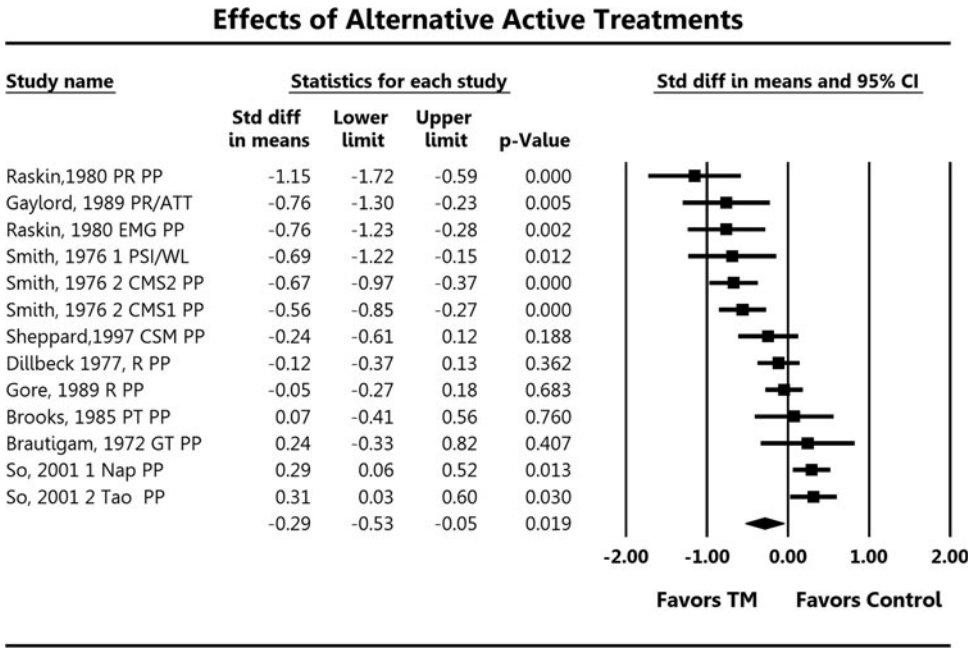

FIG. 2. Forest plot of the independent effects of active alternative treatments: PR, EMG, PSI, CMS, cortically mediated stabilization; CSM, R, PT, GT, Nap, Tao, ATT, attention control; PP, pretest-posttest; WL, wait list.

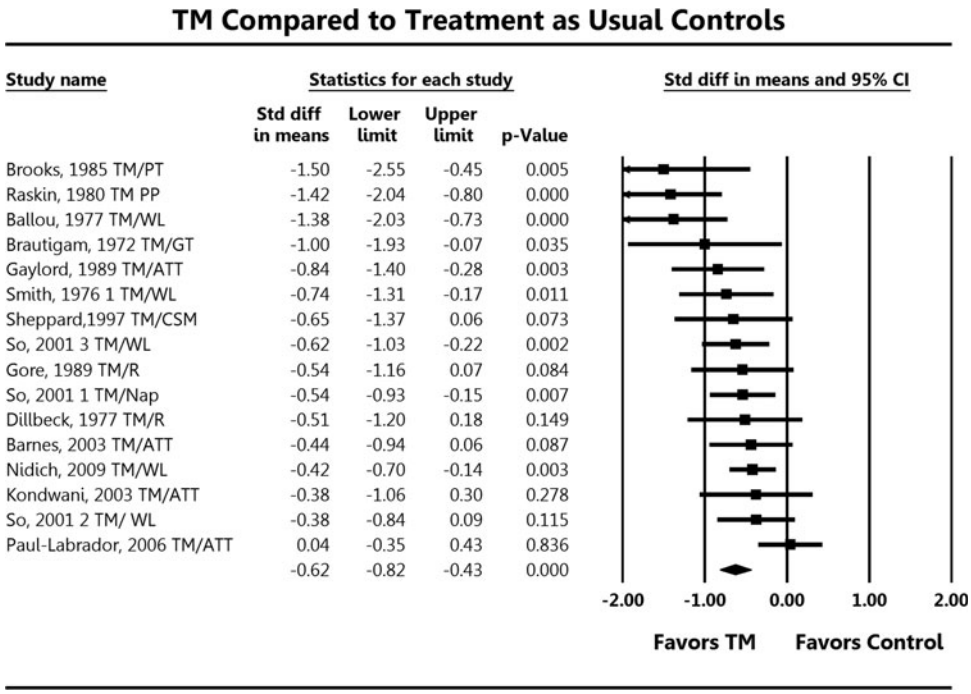

FIG. 3. Forest plot of 16 studies on Transcendental Meditation using treatment-as-usual controls.

CI, −0.53 to −0.05]; $p = 0.02$).[†††] Only six of the treatments significantly reduced anxiety: progressive muscle relaxation[40,45] or progressive muscle relaxation with electromyographic biofeedback,[45] and periodic somatic inactivity, cortically mediated stabilization-1 and cortically mediated stabilization-2.[‡‡‡47] Nonsignificant effects were found for corporate stress management,[46] simple relaxation,[39,41] psychotherapy,[38] and group therapy.[37] The control groups

[†††]Sensitivity analysis showed that when pre/post-treatment effect sizes were used for all studies (i.e., using pretest-posttest (PP) effects for the Gaylord and Smith studies instead of using attention control treatment and wait list controls, respectively), the results were highly similar ($d = -0.31$ [95% CI, −0.56 to −0.06]; $p = 0.014$).

[‡‡‡]Cortically mediated stabilization-1 and cortically mediated stabilization-2 were not directly compared with TM but were considered to be similar to TM (cortically mediated stabilization-1) or the antithesis of TM (cortically mediated stabilization-2), so they were analyzed here with alternative active treatments for interest.

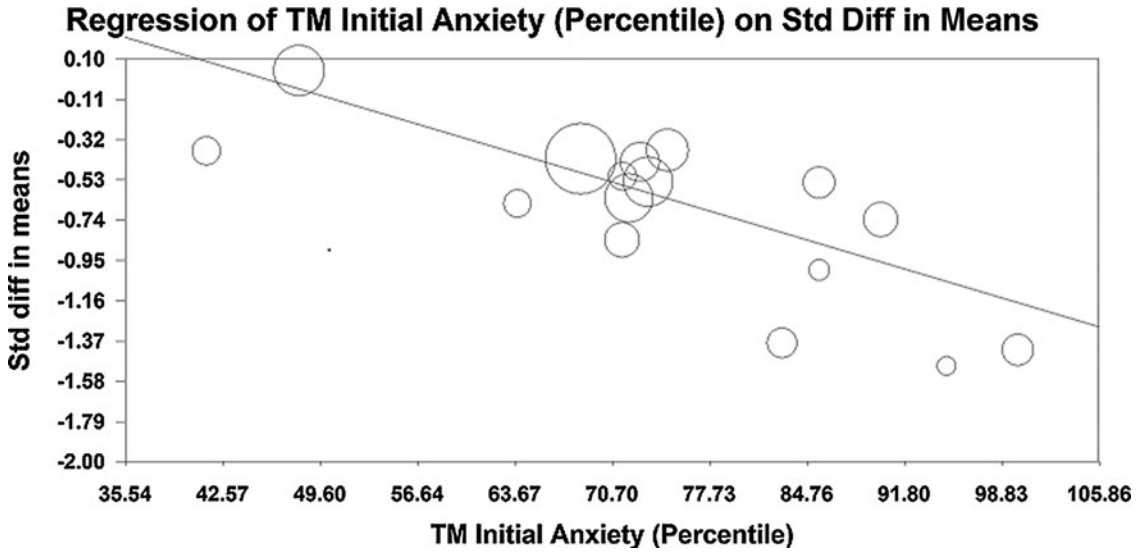

FIG. 4. Meta-regression of the standard difference in means for studies on Transcendental Meditation (d) by initial anxiety level, using the method of moments (random-effects model), showing greater reductions in effect sizes associated with high initial anxiety levels. The area of the circles is proportional to the studies' weights in the regression.

for two studies with high school students,[48] the napping and Tao groups,[§§§] showed significant increases in anxiety at posttest; this seems to have occurred because the posttest was given during exams, a time when anxiety typically increases.[32]

TM technique compared with treatment-as-usual control groups

Following Chen et al.[24] and Hofmann et al.,[25] the current study defined treatment as usual as attention control treatment and wait list controls combined, and also included ineffective alternative active control groups because they proved to only control for attention.[****] No adverse effects were reported in any of the 16 studies.

The mean effect size was $d = -0.62$ (95% CI, -0.82 to -0.43; $p = 1.37\text{E-}10$). $I^2$was 50.5, indicating that 50.5% of the variance could be attributed to heterogeneity ($Q[15] = 30.3$; $p = 0.01$) (see Figure 3). The classic fail-safe N was 339, and the Orwin fail-safe N was 73, indicating the summary effect size was robust. The wide dispersion of effect sizes was due to differences in initial anxiety levels (see below).

Meta-regression of the effects of initial anxiety level on the effect size

Figure 4 and Table 2 show that the meta-regression of initial anxiety level on effect size d was significant ($p = 0.00001$).[††††] The unexplained variance ($T^2_{\text{unexplained}}$) was 0, indicating that the initial anxiety level accounted for all of the 50.5% between-studies variance.[‡‡‡‡] The regression cannot be attributed to regression toward the mean because the treatment-as-usual controls controlled for history effects. Moreover, control groups had initial anxiety levels very similar to that of the TM groups ($r = 0.87$), and they did not show a significant regression of initial anxiety on pretest–posttest changes ($p = 0.18$), nor was their pretest–posttest effect size significantly different from 0 ($d = 0.09$ [95% CI, -0.03 to .2]; $p = 0.15$).

Table 3 shows the predicted effects size for different levels of initial anxiety and the predicted posttest anxiety level from the meta-regression.[§§§§] It can be seen that the effect size was strong ($d \approx 1.0$) for patients with initial anxiety at the 90th percentile or higher, and their anxiety would be substantially reduced to the 57th to 62nd percentile.

Other meta-regressions

Table 4 shows that age, duration of practice, compliance, and CLEAR scores were not significant predictors of d.[*****]

[§§§]The Tao meditation group was a convenience sample, not part of the RCT, but it is analyzed here for interest. It did no better than the wait list control on anxiety but improved more on inspection time ($p = 0.005$) and group embedded figures ($p = 0.057$).

[****]Pre-post effects were used for the study by Raskin et al. (1980),[45] which did not have a treatment-as-usual control.

[††††]Meta-regression on initial anxiety and other predictors used the 16 treatment-as-usual–controlled studies shown in Figure 3.

[‡‡‡‡]Recall that the total between-studies variance was indicated by the $I^2 = 50.5$ for the meta-analysis on the 16 treatment-as-usual–controlled studies shown in Figure 3.

[§§§§]Effect sizes can be considered the average percentile standing of the treatment group relative to the control group, so the percentile of the treatment group at posttest for each level of pretest anxiety was the initial anxiety level minus the percentile change relative to controls. By using negative effect sizes, the formula in Excel for predicting posttest anxiety level (X) from the regression was X = initial anxiety − (50 − NORMSDIST(d) × 100), where d is the effect size predicted from the regression equation ($d = -0.0215 \times$ initial anxiety + 0.977) for each initial level of initial anxiety.

[*****]The regression using age was marginally significant ($p = 0.11$), but this appears to be due to colinearity with initial anxiety (age and initial anxiety were correlated [$r = -0.54$; $p = 0.02$]). Normative data suggest that trait anxiety decreases with age. For example, relative to working adults (50th percentile), college students are in the 68th percentile and high school students are in the 73rd percentile.[32]

Table 2. Regression of Initial Anxiety on Effect Size (*d*) for Studies on Transcendental Meditation

Variable	*Point estimate*	*Standard error of the mean*	*Lower limit*	*Upper limit*	*Z-value*	p-*Value*	Q_{model}	*df*	p-*Value*	T^2	R^2
Slope	−0.021	0.005	−0.031	−0.012	−4.35	0.00001	18.9	1	.00001	0	1
Intercept	0.977	0.358	0.275	1.679	2.73	0.006					

The lack of association between duration of practice and *d* appears to be because the majority of anxiety reduction due to TM practice occurs in the first week or two, as found by the studies that used repeated measures.[35,41,45,46] Moreover, long-terms studies have found that reduced anxiety is maintained at 1 year[40,42,48] and 3 years[46] of TM practice.

Author affiliation

There was no evidence that papers originating from MUM and affiliates had larger effect sizes than other universities.[††††††] On the contrary, the effect sizes for studies by authors from other universities tended to be larger than those by authors associated with MUM, which was an artifact of several of the studies from other universities being conducted with high stress populations.[35,37,38,41,45]

Comparison with mindfulness-based therapy

The current results were compared with those of Hofmann and colleagues' published data on mindfulness-based therapies (MBTs),[25] using similar methods.[‡‡‡‡‡] For their 11 MBT studies using treatment-as-usual controls, the Hedges *g* was −0.33 (95% CI, −0.54 to −0.11), $Z = 2.97$; $p < 0.01$, which compares to $g = -0.61$[§§§§§] (95% CI, −0.79 to −0.42); $Z = 6.52$; $p = 7.10\text{E-}11$ for the 16 TM studies using treatment-as-usual controls, a significant difference ($Z_{diff} = 1.95$; $p = 0.05$).

Elevated anxiety

By using Hofmann and colleagues'[25] criteria of elevated anxiety,[******] the effect size of six TM studies on participants with elevated anxiety was strong ($g = -0.99$ [95% CI, −1.3 to −0.70]; $p = 1.51\text{E-}11$) compared with $g = -0.67$ (95% CI, −0.87 to −0.47; $p < .01$) for the 10 MBT studies ($Z_{diff} = 1.8$; $p = .07$ for trend). For normal anxiety levels, there was no difference between TM and MBT studies; for the TM technique, $g = -.44$ (95% CI, −0.59 to −.28; $p = 4.09\text{E-}8$); for the MBT studies, $g = -0.53$ (95% CI, −0.64 to −0.42; $p < 0.01$) ($Z_{diff} = .95$; $p = .34$).

Other outcome measures

Table 5 shows that compared with the various control groups, the TM technique decreased physiologic correlates of

Table 3. Effect Sizes Predicted from the Regression for Different Levels of Initial Anxiety and Predicted Posttest Anxiety Levels

Initial anxiety (percentile[a])	*Predicted effect size d[b]*	*Predicted posttest anxiety*
100	−1.17	62.1
90	−0.96	57.0
80	−0.74	52.9
70	−0.53	49.9
60	−0.31	47.8
50	−0.10	46.1

[a]The percentile anxiety was calculated relative to adult normative data.

[b]The predicted effect sizes from the initial anxiety levels were derived by the equation $d = -.0215 \cdot \text{initial anxiety} + 0.977$, from the regression analysis shown in Figure 4 and Table 2.

Table 4. Results of Meta-Regressions on Age, Duration of Practice, Compliance, and Clear Scores

Predictor	Q_{model}	*df*	p-*Value*
Age	2.51	1	0.11
Duration	0.04	1	0.84
Compliance	1.99	1	0.16
CLEAR	1.61	1	.20

[††††††]MUM versus other affiliation: The summary effect for MUM_1 (seven studies [40,42–44,48]) ($d = -0.43$ [95% CI, −0.65 to −0.22]; $p = 0.0001$) was significantly less than for $other_1$ (nine studies),[35–39,41,45–47] ($d = -0.84$ [95% CI, −1.09 to −0.58]; $p = 2.18\text{E-}10$; $Z_{diff} = 2.34$; $p = .02$). The difference between MUM_1 and $other_1$ was an artifact of several of the $other_1$ studies conducted with high-stress populations.[35,37,38,41,45]

Effect size for MUM_2 (10 studies, $MIU_1 + 3$[35,37,41]) ($d = -0.53$ [95% CI, −.74 to −.32]; $p = 1.12\text{E-}06$), was also less (not significant) than that of $other_2$ (six studies) ($d = -0.77$ [95% CI, −1.09 to −0.45]; $p = 3.088\text{E-}6$; $Z_{diff} = 1.47$; $p = .23$).

MUM_3 (13 studies: $MUM_2 + 3$[36,39,46]) also had a significantly lower effect size ($d = -0.52$ [95% CI, −0.69 to 0.34]; $p = 4.70\text{E-}09$) than did $other_3$ ($d = -1.07$ [95% CI, −1.51 to −.62]; $p = 1.12\text{-}06$; $Z_{diff} = 2.27$; $p = 0.02$), again because the $other_3$ were studies conducted in patients with high anxiety.

[‡‡‡‡‡]To make the data comparable to those of Hofmann and colleagues, the current analysis used the Hedges *g*, random-effects model, standardized on post-treatment standard deviations, and set the pretest to posttest reliability for all tests at 0.7 as they did. One difference is that they used uncontrolled pretest–posttest effect sizes and the current analysis used RCTs with treatment-as-usual controls, as shown in Figure 3. Raskin and colleagues' study was included even though the patients were diagnosed with an anxiety disorder, which was an exclusion criterion for Hofmann et al. However, leaving out the study by Raskin et al. did not appreciably change the effect sizes for TM studies ($g = -0.91$ [95% CI, −1.2 to −0.59]; $p = 2.04\text{E-}08$).

[§§§§§] Note that the Hedges' *g* (−0.61) was only slightly less than the standard difference in the means *d* (−0.62) shown in Figure 3 for the 16 treatment-as-usual–controlled TM studies.

[******]Hofmann et al.[25] defined elevated pretreatment anxiety as above the clinical cutoff score suggested by test manuals, which for the State-Trait Inventory was a score of 40, corresponding to the 71st percentile relative to working adults. Study populations were classified as having elevated anxiety if the lower bounds of the 95% CIs for the pretreatment means were above the cutoff score, that is, almost all of the patients had anxiety levels greater than or equal to the 71st percentile. The mean pretest anxiety level (±standard deviation) of the six TM studies that met these criteria was 90th percentile ± 6.2.

Table 5. Effects of Transcendental Meditation Practice on Other Outcome Measures for the Randomized Controlled Trials that Included Anxiety

Study, year	*Population*	*Results on other outcome measures in TM participants compared with treatment-as-usual controls*
Ballou, 1977[35]	Prisoners	Prison rule infractions decreased two thirds, no change in controls. Hours per week participating in recreational and educational activities tripled ($p < 0.01$).
Barnes, et al., 2003[36]	Prehypertensive adolescents	Decreased absentees ($p < .05$), decreased infractions ($p < .03$), decreased suspension days due to behavior-related problems ($p < .04$). This study ($n = 45$) was a subsample of a larger parent study (n = 156) that found decreased daytime systolic ($p < .04$) and diastolic ($p < .06$) ambulatory blood pressure[50] and reduction in left ventricular mass index ($p < .04$) and less increase in body–mass index than in controls ($p < .03$).[51]
Brautigam, 1972[37]	Drug rehabilitation clients	Decreased use of all categories of drugs ($p < .01$), including decreased use of hashish ($p < .01$) and hard drugs (LSD, amphetamines, opiates) ($p < .01$). Increased time spent in work and leisure time activities ($p < .001$). Increased psychological stability ($p < .025$), adjustment ($p < .005$) and self-confidence ($p < .10$, trend), and decreased tension-restlessness ($p < .001$), psychomotor retardation ($p < .025$), and flaccidity ($p < .005$).[a] No change in extroversion ($p < .20$).
Brooks and Scarano, 1985[38]	Veterans with PTSD	Decreased PTSD ($p < .05$), decreased PTSD subscales for emotional numbness ($p < .025$), depression ($p < .025$), alcohol consumption ($p < .005$), insomnia ($p < .001$), and family problems ($p < .05$). Improved employment status ($p < .01$). Faster habituation response to a stressful stimulus ($p < .10$, trend).
Dillbeck, 1977[39]	College students	Measured anxiety only.
Gaylord et al., 1989[40]	College students	Both TM and PR groups increased on an overall mental health factor relative to ATT controls ($p < .04$). TM reduced neuroticism more than did PR and ATT ($p < .03$). Increased frontal and central alpha and theta EEG coherence during TM ($p < .02$), but not during PR or ATT. More rapid skin potential habituation to a stressor for TM but not PR ($p < .05$).
Gore et al., 1984[41] #1	Prison inmates	Significant decrease in skin conductance during TM ($p < .025$). Decreased sleep disturbance ($p < .05$), decreased paranoid anxiety ($p < .05$), increased locus of control ($p < .05$). No significant changes in cigarette and caffeine consumption, hostility, and skin conductance response to the cold stressor test.
Gore et al., 1984[41] #2	Prison inmates	Decreased sleep disturbance ($p < .0001$), paranoid anxiety ($p < .0001$), hostility ($p < .0001$) and anger control ($p < .002$), increased locus of control ($p < .0001$).
Gore et al., 1984[41] #3	Prison staff	Decreased sleep disturbance ($p < .005$), paranoid anxiety ($p < .001$), hostility ($p < .05$). No significant change in locus of control.
Kondwani, et al., 2003[42]	Hypertensive patients	Decreased diastolic blood pressure (change, (3.70 mmHg, $p < .009$), decrease in ventricular septal thickness ($p < .009$), decreased left ventricular mass index for TM and health education controls ($p < .01$). Increased energy ($p < .01$), positive affect ($p < .01$), behavioral/emotional control ($p < .001$), and decreased sleep dysfunction ($p < .001$), physical symptoms of distress ($p < .02$), and depression ($p < .02$), social desirability ($p < .30$).
Nidich, et. al., 2009[43]	College students	Decreased blood pressure in hypertension risk subgroup ($p < .02$ systolic, $p < .03$ diastolic), but not in normotensive participants. Decreased psychological distress ($p < .05$), depression ($p < .05$), anger/hostility ($p < .05$), and coping ($p < .05$). Reductions in anxiety, depression, and coping ability were significantly correlated with systolic and diastolic blood pressure ($r \approx 0.21$, $p \approx .03$).

(*continued*)

Table 5. (Continued)

Study, year	*Population*	*Results on other outcome measures in TM participants compared with treatment-as-usual controls*
Paul-Labrador et al., 2006[44]	Patients with coronary heart disease	Improved metabolic syndrome: decreased systolic blood pressure ($p < .04$), decreased insulin resistance ($p < .01$), improved cardiac autonomic nervous system tone (heart rate variability [$p < .07$]).
Raskin et al., 1980[45]	Volunteers diagnosed with anxiety neurosis	Reduced EMG muscle tension ($p < .05$), improved current mood (state anxiety) ($p < .01$), and reduced situational discomfort and symptomatic distress ($p < .01$) in all groups (TM, PR, and EMG). No significant improvement in sleep.
Sheppard et al., 1997[46]	High-security government agency staff	Reduced state anxiety ($p < .025$), depression ($p < .01$), improved self-concept ($p < .025$), maintained after 3 years. No significant changes in blood pressure (in normotensive participants).
Smith, 1976,[47] #1	High-anxiety college students	Decreased symptoms of striated muscle tension ($p < .008$) and symptoms of autonomic arousal ($p < .04$) in TM as well as PSI compared with WL control.
Smith, 1976,[47] #2	High-anxiety college students	Decreased pretest–posttest levels of symptoms of striated muscle tension ($p < .008$) and symptoms of autonomic arousal ($p < .04$) for both CMS_1 and CMS_2 ($p < .08$ to $.001$).
So and Orme-Johnson, 2001,[48] #1	High school students	Test for Creative Thinking-Drawing Production ($p < .003$), Constructive Thinking Inventory ($p < .001$), Group Embedded Figures Test ($p < .001$), State Anxiety ($p < .001$), Inspection Time ($p < .001$), and Culture Fair Intelligence Test ($p < .16$).
So and Orme-Johnson, 2001,[48] #2	High school students	Test for Creative Thinking-Drawing Production ($p < .0001$), Constructive Thinking Inventory ($p < .001$), Group Embedded Figures Test ($p < .01$), State Anxiety ($p < .02$), Inspection Time ($p < .001$), and Culture Fair Intelligence Test ($p < .03$).
So and Orme-Johnson, 2001,[48] #3	High school students	Test for Creative Thinking-Drawing Production ($p < .001$), Constructive Thinking Inventory ($p < .001$), Group Embedded Figures Test ($p < .001$), State Anxiety ($p < .001$), Inspection Time ($p < .002$), and Culture Fair Intelligence Test ($p < .04$).

[a]Tension-restlessness, psychomotor retardation, and flaccidity were scales from observational assessments form. The scores were the ratings by an independent psychologist and psychiatrist who were blind to the participants' group assignment. The forms are concerned with the observation and rating of specific overt features of behavior, such as facial expression, posture, movement, and manner of speaking, that are symptomatic of depression and tension.

EEG, electroencephalography; LSD, lysergic acid diethylamide; PR, progressive relaxation; PSI, periodic somatic inactivity.

anxiety, depression, sleep problems, and substance abuse and improved affect, stress reactivity, and behavioral outcomes.

Discussion

The effect size of the TM technique on reducing trait anxiety depends on the patients' initial anxiety level. For patients with anxiety in the 90th percentile, the standard difference in the means is large ($d \geq -1.0$). The principle that populations with elevated initial levels of an outcome will show larger effect sizes appears to also hold for other variables, such as depression[25] and blood pressure.[43] One implication of this finding for future meta-analyses is that to make meaningful comparisons between treatments, the treatments must be similar with regard to initial levels on the outcome measure.

The current analysis identified substantially more RCTs on the TM technique and trait anxiety than did other meta-analyses,[23,24] apparently because it included a comprehensive annotated bibliography of TM studies in the search.[52] Future reviewers should also include this and other online bibliographies dedicated to meditation research, including the Meditation Bibliography maintained by the Institute of Noetic Sciences,[53] the Mindfulness Research Guide,[54] and the Qigong Institute's database.[55]

The current analysis found no evidence that the effect sizes of studies conducted by authors affiliated with MUM were larger than those of studies from independent universities, which is in accordance with a previous meta-analysis.[22]

The finding of this meta-analysis that the TM technique produced larger effects on reducing trait anxiety than MBT, as reported by Hofmann et al.,[25] is in accordance with previous meta-analyses indicating that the TM technique produces greater reductions in trait anxiety than mindfulness or other meditation and relaxation practices.[22,23] However, in the present meta-analysis, progressive relaxation was as effective as the TM technique in reducing trait anxiety,[40,45] but

it did not have as great an effect in reducing neuroticism or autonomic stress reactivity and did not increase frontal and central alpha EEG coherence as TM practice did.[40] The placebo control in the Smith study[47] also decreased anxiety as well as did the TM technique, but the long-term effects of TM practice on a wide array of objective physiologic and medical correlates of stress, such as heart attacks, strokes, and death,[56,57] strongly indicate that its effects are not solely due to placebo.

A limitation of this meta-analysis is that it included only one study on patients with a clinically diagnosed anxiety disorder,[45] although TM practice did have large effects on other high-stress groups (patients with post-traumatic stress disorder,[38] prison inmates,[35,41] and drug rehabilitation clients[37]) who were not formally diagnosed with an anxiety disorder. Twelve different categories of anxiety disorders are described by the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders*,[58] and more research is needed on each of them. Although no adverse effects were found in this or previous meta-analyses,[22,23,59] the policy of the TM teaching organization[60] is that diagnosed psychiatric and medical populations learn the technique under medical supervision until they are clinically assessed to be well enough to be on their own. However, because TM practice reduces not only self-reported anxiety but also autonomic, medical, and behavioral correlates of anxiety, TM may be a beneficial adjunct to medical treatment for anxiety disorders just as it is beneficial for undiagnosed anxiety. Given the enormous toll anxiety places on the national health care bill, not to mention the widespread human suffering it causes, it would appear that the TM would be a valuable and cost-effective option.

Author Disclosure Statement

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