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## Psychosocial Stress and Cardiovascular Disease Part 2: Effectiveness of the *Transcendental Meditation* Program in Treatment and Prevention

**Kenneth G. Walton, PhD, Robert H. Schneider, MD, Sanford I. Nidich, EdD, John W. Salerno, PhD, Cheryl K. Nordstrom, PhD, MPH, and C. Noel Bairey Merz, MD**

is a senior fellow at the Center for Natural Medicine and Prevention at Maharishi University of Management, Fairfield, Iowa, where **Dr Schneider** is director of the center; **Dr Nidich** is a professor with the Center for Natural Medicine and Prevention; **Dr Salerno** is assistant director and an assistant professor; **Dr Nordstrom** is director of cardiology, biostatistics, and epidemiology at St John Hospital and Medical Center in Detroit, Michigan; and **Dr Bairey Merz** is director of the Preventive and Rehabilitative Cardiac Center at Cedars-Sinai Medical Center, Los Angeles, and an associate professor of clinical medicine at the University of California–Los Angeles (UCLA) School of Medicine.

### Abstract

Psychosocial stress is a nontraditional risk factor for cardiovascular morbidity and mortality that may respond to behavioral or psychosocial interventions. To date, studies applying such interventions have reported a wide range of success rates in treatment or prevention of cardiovascular disease (CVD). The authors focus on a natural medicine approach that research indicates reduces both psychosocial and traditional risk factors for cardiovascular disease—the *Transcendental Meditation (TM)* program. Randomized controlled trials, meta-analyses, and other controlled studies indicate this meditation technique reduces risk factors and can slow or reverse the progression of pathophysiological changes underlying cardiovascular disease. Studies with this technique have revealed reductions in blood pressure, carotid artery intima-media thickness, myocardial ischemia, left ventricular hypertrophy, mortality, and other relevant outcomes. The magnitudes of these effects compare favorably with those of conventional interventions for secondary prevention.

### Index Terms

cardiovascular disease; psychosocial stress; review; Transcendental Meditation

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A growing body of research supports the proposal that psychosocial stress is an important risk factor for cardiovascular disease (CVD) as reviewed in Part 1 of this series<sup>1</sup> and elsewhere.<sup>2–5</sup> Psychosocial stress contributes not only to CVD risk factors (eg, high blood pressure, elevated cholesterol, insulin resistance/diabetes, high use of tobacco and alcohol, and stress reactivity of the cardiovascular system), but it is also implicated in the progression of CVD. All major stages along a chain of pathophysiological events that culminate in mortality appear to be affected, including clustering of traditional risk factors, endothelial function, atherosclerosis, myocardial ischemia, plaque rupture, thrombosis, and lethal arrhythmias.<sup>1</sup>

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For comments and further information, please address correspondence to Kenneth G. Walton, Center for Natural Medicine and Prevention, 504 North Fourth Street, Suite 204, Fairfield, IA 52556 (e-mail: k Walton@mum.edu).

Part 3 of this series will be published in a future issue of *Behavioral Medicine*.

## The *Transcendental Meditation (TM)* Program as an Intervention for Psychosocial Stress and CVD

Evidence for the multiple roles of psychosocial stress in CVD reviewed elsewhere<sup>6–9</sup> indicates that interventions designed to address psychosocial factors might be expected to reduce recurrent CVD events. This appears to be the case. Trials of a variety of psychosocial interventions have found reductions in recurrent cardiac events, sometimes surpassing 50%. However, such large effects tend not to be replicated in the larger follow-up studies, and some results have been found to be short-lived.<sup>9–11</sup>

The cause of reported discrepancies in outcomes has not been directly demonstrated. However, quantitative meta-analyses of various approaches, including different types of meditation, suggest that the specific psychosocial intervention used may be a critical factor (see Orme-Johnson & Walton<sup>12</sup> for review). Murphy<sup>13</sup> reached a similar conclusion after examining a large body of research on stress management in work settings. A review of all meta-analyses on stress-reduction approaches available in 1997 (10 meta-analyses covering a total of 475 studies and 21 approaches) led us to conclude not only that different approaches have different effects, but also that those based on traditions spanning centuries (eg, the Vedic and Zen traditions) tended to prove more beneficial than their recent, clinically devised counterparts.<sup>12</sup>

Meditation techniques vary widely, as do other psychosocial interventions, in what takes place during the sessions and in their effectiveness at producing measured outcomes.<sup>12</sup> According to Murphy and associates,<sup>14</sup> updated bibliography of research on meditation, the *Transcendental Meditation (TM)* program has been investigated more extensively than any other method. This is especially true of research in the area of CVD. Because meta-analyses as well as direct comparisons have revealed that the TM technique is 2 to 3 times as effective as comparison approaches on most outcomes, we focus only on the TM program in this article.

### Nature of the *TM* Program

The main component of the TM program is a systematic, psychophysiological procedure based in the ancient Vedic tradition.<sup>15</sup> The technique, which is understood to be a comprehensive means of enhancing human health and awareness, is a principal component of the Maharishi Vedic Medicine program, a natural health-promotion technology that includes all 40 different approaches of the Vedic tradition.<sup>16–18</sup> Five volumes of collected papers contain 430 of the more than 600 published studies on the TM program,<sup>19–21</sup> and volumes 6 and 7 are in preparation. Many of these papers report research relevant to CVD. However, because of space limitations, we focus primarily on studies directly examining CVD risk factors and other CVD-related outcomes (a broader range of TM research literature can be found elsewhere<sup>15,22,23</sup>).

The TM program is taught by trained professionals through a standardized instruction procedure.<sup>24</sup> Over the past 40 years, more than 6 million people around the world have been instructed in the program, which continues to be offered in larger cities in most countries. The technique is easy to learn and enjoyable to practice. Generally, compliance with the recommended practice of 15 to 20 minutes twice a day is high. Part 3 of this series, to be published in a future issue of *Behavioral Medicine*, will provide a detailed summary of characteristics of the TM program and describe how it is taught.

### A Working Model of Psychosocial Stress and CVD

In this article, we elaborate on our model of the etiology and progression of CVD<sup>1</sup> that we described in Part 1 of this series to illustrate some of the possible interactions and pathways involved in the effects of psychosocial interventions on CVD morbidity and mortality outcomes

(see Figure 1). In brief, psychosocial stress associated with low socioeconomic status (ie, low levels of education, occupation, and income),<sup>25</sup> adverse life events (eg, job loss, bereavement, and divorce),<sup>26</sup> and high job strain<sup>27,28</sup> may contribute to emotional and behavioral responses such as anger, hostility, depression, anxiety, and social isolation.

These maladaptive responses, in turn, have a negative impact on the cardiovascular system through physiologic mechanisms such as sympathetic hyperactivity, oxidative stress, and neuroendocrine imbalances.<sup>5</sup> Each of these physiologic mechanisms may influence 1 or more of the traditional cardiovascular risk factors and increase cardiovascular morbidity and mortality. Psychosocial moderators such as social support and coping strategies can play an important role in modulating or preventing maladaptive behaviors.<sup>25</sup> In this model, the TM program might best fit under the heading of moderating influences, altering the psychological effects of stressors, but evidence also suggests that it can have direct effects on physiological systems that mediate the stress response. Much research remains to be done, however, to elucidate the physiological and psychological mechanisms responsible for the beneficial effects of the TM program and the relationship of these effects to those of other moderating influences and other approaches to psychosocial intervention. (Part 3 of this series will provide a discussion of the mechanisms mediating the effects of this program.)

## Review of *TM* Research on CVD Risk Factors, Morbidity, and Mortality

This review focuses on all controlled studies in the last 15 years, located by computer searches through May 2002. We conducted searches using PubMed (containing citations from Medline and several other sources), FirstSearch (containing citations from 59 different indexes), and Electronic Library. Because of the large number of controlled studies in the areas of substance abuse and psychological indicators of stress, we restricted our reviews of these areas to quantitative meta-analyses and randomized controlled trials.

The data in Table 1 summarize all references found on effects of the TM program on traditional and putative risk factors for CVD<sup>29</sup> and provide the citation, field location, study design, sample size, control intervention(s), follow-up period, measures, and outcomes. We performed searches under each risk factor. The meta-analyses and randomized controlled trials of the effects of the TM program on the signs or consequences of psychosocial stress, including various categories of psychopathology and mental and psychological health, are listed in Table 2. The data in Table 3 summarize studies reflecting effects of the program on the mechanisms or physiological consequences of stress that are thought to contribute to CVD, and the data in Table 4 summarize studies on the effects of the program on CVD morbidity and mortality. Because of space limitations, we describe the collective outcomes and notable strengths or weaknesses of the studies in the text.

## Reductions in Risk Factors for CVD

### High Blood Pressure

Five studies of the effects of the TM program on blood pressure (BP) have been published in the last 15 years (see Table 1). Significant reductions of blood pressure—up to 13 mm Hg in systolic blood pressure (SBP) and 8 mm Hg in diastolic (DBP) were reported in each study, which was consistent with results of earlier studies.<sup>30,31</sup> Four of these studies were independent randomized clinical trials (RCTs). The fifth study, also randomized, was a subgroup analysis of data from 1 of the 4 trials and therefore was not independent. Two of the RCTs were performed among African American participants and 2 among White Americans.

The ages of participants varied from study to study but ranged from adolescence to old age. The pretreatment BP also varied, including individuals whose levels were normal, high normal,

and hypertensive (> 139 SBP and > 89 DBP). Most studies used resting BP in the laboratory, but 1 study also used ambulatory measurements. The greatest shortcoming of the RCTs on blood pressure so far is the relatively short time of follow-up—the longest was only 4 months.

Strong points of these studies were (1) their demonstration that the TM program can be effectively implemented in widely different populations, from African American adolescents to older African Americans in lower socioeconomic, inner-city communities, to a higher socioeconomic group of White Americans in homes for the elderly; (2) a generally high compliance with the program, with participants in an inner-city, older African American sample showing 97% compliance with the recommended twice daily home practice of the TM program<sup>30</sup>; (3) the demonstration of significant BP reductions in participants of both sexes and at both ends of the spectrum of CVD risk<sup>31</sup>; and (4) that the TM program was twice as effective in reducing the BP of hypertensive older African Americans as was progressive muscle relaxation, which itself lowered BP significantly.<sup>30,31</sup> The TM program's effects on blood pressure were also clinically significant, as inferred from trials on antihypertensive drugs in which similar reductions in blood pressure produced substantial reductions in cardiovascular morbidity and mortality.<sup>39,40</sup>

### Lipids and Cholesterol

An earlier prospective, controlled study showed a 10% decline in plasma total cholesterol in medication-free, hypercholesterolemic volunteers without heart, renal, or thyroid disorders after 11 months on the TM program, compared with matched controls.<sup>41</sup> The latest studies examined individuals who were less hypercholesterolemic than the participants in the earlier study (ie, pretreatment means for the later studies were 213 and 193 mg/dL, compared with 257 for the earlier study). De Armond's study<sup>35</sup> of executives and managers reported a significantly lower cholesterol level after 3 months of TM, compared with controls, despite the low pretest cholesterol level (mean of 193 mg/dL). The failure of the Calderon study<sup>37</sup> to find a significant cholesterol reduction in the TM group compared with controls may have been a result of significant differences in dietary improvements. The health education controls received dietary instruction that resulted in significantly greater improvements in factors related to cholesterol levels. Those patients' diet questionnaires showed greater reductions than did the TM group in total fat, cholesterol (trend), fiber, saturated fat, percentage of calories from fat, percentage of calories from sweets, and total caloric intake.

Growing research evidence suggests that it is not cholesterol levels per se that contribute to atherosclerosis and heart disease but rather the level of oxidized cholesterol and oxidized lipids.<sup>42,43</sup> Excessive free radicals of oxygen are recognized as the cause of oxidation of lipids and cholesterol and are now supported as a major contributor to the mechanisms underlying atherosclerotic CVD.<sup>44</sup> In our literature search, we found 1 study on the effects of the TM program in reducing oxidative stress.<sup>36</sup> This observational study of lipid peroxide levels in serum suggested that the TM program reduces oxidative stress, an effect that, if large enough, might account for some of the reduced atherosclerosis resulting from the program (see Table 4).

### Tobacco and Other Substance Abuse

Because the quantitative meta-analysis<sup>38</sup> shown in Table 1 included all TM studies on substance abuse published in the last 15 years (and earlier), only this meta-analysis was listed. This meta-analysis of 19 studies combined results from 4,524 participants—adolescents, college students, working adults, elderly African Americans, criminal offenders, Vietnam veterans, and skid-row alcoholics—and controlled for strength of study design. The effect sizes obtained were large and highly significant, especially the .87 effect size for cigarette use.

### High Reactivity or Shear Stress

Elevated cardiovascular responses to stress are considered by some to reflect higher risk for hypertension and CVD.<sup>45,46</sup> Two studies have examined the effects of the TM program on this variable. One, in African American adolescents with high normal BP,<sup>34</sup> found that 2 months of the TM program significantly reduced the reactivity of SBP, cardiac output, and heart rate, with a trend toward reduced DBP. The other study, conducted among male college students, found a significantly increased SBP reactivity after 4 months of TM in the high-compliance TM participants, compared with the high-compliance educational control participants, but the researchers did not measure other indicators of hemodynamic functioning in that study.<sup>33</sup>

### Changes in Psychologic Indicators and Consequences of Psychosocial Stress

The ability of the TM program to prevent or reverse psychologic indicators or effects of psychosocial stress has been the most active area of TM research. Because hundreds of studies in this area are available, we have chosen to present only the quantitative meta-analyses and RCTs. Individual studies have reported that the program reduces negative indicators of stress (eg, anger, hostility, anxiety, and depression) and elevates positive indicators of mental health (eg, self-concept, internal locus of control, and self-actualization). See Hawkins<sup>23</sup> for citations of many of the individual studies. Findings from meta-analyses controlled for strength of design, length of time practicing, and sometimes for experimenter bias and pretest demographics have confirmed most of the positive effects.

The meta-analyses found that the TM program was 2 to 3 times as effective as comparison programs, a finding that was consistent with the meta-analyses on substance abuse mentioned earlier.<sup>38</sup> This differential between TM and comparison interventions was independent of the strength of the research design. The order of increasing design strength generally consisted of (from lowest to highest) participants being used as their own controls, nonrandom assignment to groups, random assignment to groups, and random assignment with low attrition (less than 15%).

### Effects on Physiologic Mechanisms: Physiologic Indicators or Consequences of Stress

In our working model (Figure 1), we propose a variety of physiologic systems to mediate the effects of psychosocial stress on cardiovascular health. Several studies indicate that the TM program has effects on these systems. In addition to the possible indirect effects arising from changes in psychological states such as anxiety and anger, there may be direct, acute effects of the program on physiologic systems involved in the stress response,<sup>51,52</sup> a possibility to be discussed further in Part 3 of this series.

Research in the last 15 years can be grouped in 3 main areas, as were those in previous investigations of the effects of the TM programs on physical indicators and consequences of stress: (1) activity of neuronal systems, especially the sympathetic nervous system (SNS); (2) activity of the hypothalamic-pituitary-adrenocortical (HPA) axis or other hormonal systems; and (3) effects on skin resistance (thought to reflect SNS activity). Although some earlier studies (eg, Michaels and associates<sup>53</sup>) did not find effects of the TM program in some of these areas, those studies involved small numbers of participants and may have lacked the statistical power to detect changes. Or, as suggested in a later review,<sup>52</sup> the research design of these studies reduced the likelihood of seeing significant effects.

In the studies shown in Table 3, significant differences apparently due to the TM program were found in each of the earlier-mentioned 3 categories, using various research designs. Most of the results of these studies can be interpreted as indications that the TM program reduces stress or reduces the signs of chronic stress. Thus, results of 5 controlled studies (2 with random assignment of participants<sup>48,55</sup>) suggested reductions of sympathetic activity or sympathetic tone; results of 3 studies (2 with random assignment<sup>57,58</sup>) indicated there was reduced or more normal activity of the HPA axis; the findings in 2 studies (1 randomized<sup>57</sup>) suggested an increase of serotonergic activity along with a reduction in HPA-axis activity; and 1 quantitative meta-analysis indicated that a single TM program session affected basal skin resistance, respiratory rate, and plasma lactate in a direction opposite from stress.<sup>52</sup> This meta-analysis also found that TM practitioners showed signs of lower chronic stress (ie, their values before the meditation session were significantly lower than those of controls on spontaneous galvanic skin responses, respiratory rate, heart rate, and plasma lactate). Because many studies have found that the effects observed during individual sessions of the TM program become increasingly more noticeable outside the sessions over time, these baseline differences probably reflect the cumulative effects of the regular twice-daily practice of the TM technique. Alternatively, in studies in which random assignment to a group was not used, the results might reflect preexisting physiologic differences specific to the individuals who volunteered for the study because they were interested in learning TM. This explanation is not likely, however, because authors of other studies (eg, Alexander and associates<sup>62</sup>) did not find that volunteers interested in learning TM were different from those not interested.

### **Hemodynamic Function**

One observational study that compared long-term practitioners of the TM program with nonpractitioner controls provided evidence that the TM program led to reduction of hemodynamic vasomotor dysfunction (vasomotor dysfunction is one of the earliest signs of CVD).<sup>1</sup> In an eyes-open rest period prior to the practice of TM (or of eyes-closed rest in controls), SBP and total peripheral resistance both significantly decreased, and cardiac output significantly increased in the TM group, relative to controls. During the TM session, decreases in SBP and total peripheral resistance and an increase in cardiac output occurred, but the latter change did not reach the  $p = .05$  level.

### **Reductions in CVD Morbidity and Mortality**

Because of research indicating that the TM program reduces CVD risk factors and the possible physiologic mediators between stress and CVD, reductions in morbidity and mortality also would be expected. Several studies have investigated such outcomes, and so far the research findings support this conclusion (Table 4).

### **Regression of Atherosclerosis**

Authors of 2 reports of studies in which the TM program was a main component of the intervention reported reductions in atherosclerosis (Table 4). The first study involved the TM program as the only intervention, beyond routine care by the patient's usual physicians.<sup>63</sup> The most recent study, a multimodality intervention, used the TM program along with 3 other components of the approach called Maharishi Vedic Medicine (MVM).<sup>64</sup> Both trials reported significant reductions in atherosclerosis, as indicated by carotid artery intima-media thickness, that is both a direct measure of carotid artery atherosclerosis, and a surrogate measure of coronary atherosclerosis.<sup>65</sup> Participants in the more recent study were normally healthy, older White Americans, and the earlier study participants were African American individuals with hypertension.

Although the numbers of volunteers in these trials were small, the effects found were not, especially in subjects with risk factors for CVD. The results are not only statistically significant, but in all probability clinically significant. Based on other studies,<sup>68</sup> these 10% to 20% reductions in intima-media thickness are likely to reflect as much as 33% reduction in the risk of myocardial infarction or stroke.

Measures of blood pressure and other risk factors in these subjects before and after intervention did not show significant differences between groups. However, the within-group decreases in these risk factors were significant enough to suggest they may have contributed to the reduced intima-media thickness. Other factors that were not measured also may be involved; thus additional research is necessary to clarify the mechanisms of these apparent reductions in atherosclerosis.

### **Left-Ventricular Hypertrophy**

Regression of left ventricular mass (LVM) in animal models and in humans with left ventricular hypertrophy has been associated with improvement in diastolic function, reduced arrhythmias, and the preservation of systolic function.<sup>69</sup> A randomized, controlled study of mildly hypertensive African Americans (DBP = 90 to 104 mmHg) in West Oakland, California, found that both the TM program and a modern Health Education program significantly reduced LVM and LVM indexed to body mass.<sup>66,70</sup> However, the TM group also showed a significant mean decrease in DBP ( $p < .01$ ), whereas the Health Education group did not change significantly in either diastolic or systolic blood pressure.

The decrease of LVM with these psychosocial interventions is large enough to be clinically significant, comparing favorably with studies on antihypertensive medications where the reduction in mass index was 8%–12%. A review of the literature indicates that a 10% decrease would substantially reduce the occurrence of clinical CVD events.<sup>71–73</sup>

### **Reduction in Myocardial Ischemia**

In a pilot RCT of effects of the TM program on myocardial ischemia, Zamorra, et al.<sup>67</sup> found that exercise-induced myocardial ischemia in coronary heart disease patients was reduced in the TM group relative to a control cardiac care group. The TM group also showed significant increases in exercise tolerance, maximum workload, and delay of onset of ST segment depression compared with the control group.

### **Reductions in Mortality**

Arguably the most critical outcome measure for CVD is mortality. Mortality data on the TM program have been analyzed in several studies, but the results of only one study have yet appeared in a full-length article. Alexander et al. conducted a randomized controlled trial of ambulatory, non-institutionalized, elderly subjects in Massachusetts rest homes.<sup>32</sup> Of these, 82% were women with high normal blood pressure and stage 1 hypertension. Mean age of the subjects at the outset was 81 years. Effects of the TM program were compared with effects of three other conditions: mindfulness training, a relaxation response-type technique, and usual medical care. Over a 3-year period, the survival rate in the TM group was 100%, compared with 87% for the mindfulness group, 77% for the usual care group, 65% for the relaxation-response group, and 62.5% for all others in the homes. The TM group also showed an improvement in SBP (–12 mm Hg) that was significantly larger than in the other groups, and improved most on multiple measures of cognitive and social functioning.

After 15 years, mortality data for the participants in this study were obtained from the National Death Index and analyzed using the Cox proportional hazards model for survival.<sup>74</sup> Adjusting for age, gender, and pretest SBP, CVD mortality rate was significantly lower for the TM group

than for the combined controls ( $p = 0.03$ ,  $RR = 0.56$ ). Risk for CVD mortality was 44% lower in the TM group. (Full-length publication of the follow-up study on this research was prevented by the untimely death of Dr Alexander, the principal investigator, in May 1998.)

## Comment

The present summary of CVD-relevant research on the TM program provides important information for gauging this program's effectiveness in treating and preventing CVD. The recent pilot randomized clinical trials showing reductions in atherosclerosis may represent the most significant evidence of the effectiveness of this program. Other results, indicating reduction of hemodynamics dysfunction, regression of left-ventricular mass, reduction of myocardial ischemia, decreased blood pressure, and reduced mortality, also support the ability of this program to positively affect the symptoms and progression of CVD.

All the randomized controlled trials and controlled studies listed here for CVD risk factors, morbidity, and mortality involved relatively small numbers of subjects and bear repetition. However, the research on factors representing psychosocial stress is more voluminous. The beneficial effects of the TM program on a wide spectrum of measures of psychosocial risk, such as anger and anger control, hostility, anxiety, depression, perceived health, and resistance resources, may help to explain significant effects of the TM program on CVD morbidity and mortality.

Part 3 of this series will include a discussion of issues important in further evaluating the practical use of this intervention in large-scale community settings. These include: (a) degree of standardization of instructional procedures, (b) availability of properly trained instructors, (c) degree of difficulty of the intervention—competency of patients to comply, (d) prior record of patient compliance with the intervention, (e) the cost of instruction, and (f) an empirically testable hypothesis or theory by which to understand the intervention and its effectiveness.

## Summary and Synthesis

The importance of psychosocial stress as a contributor to CVD's progression and prognosis is becoming widely recognized. Reductions in recurrent cardiac events and death have been reported for the most successful psychosocial approaches, and the magnitude of these reductions is similar to that of other proven therapies, such as lipid lowering, anti-platelet therapy, beta-blocker medication, and bypass surgery. The Transcendental Meditation program is a standardized behavioral intervention with holistic effects. The evidence summarized herein supports the ability of this program to reduce both psychosocial and traditional risk factors and to halt or reverse pathophysiological mechanisms underlying CVD progression and death. Other findings with regard to the community-wide application of this approach are covered in Part 3 of this series.

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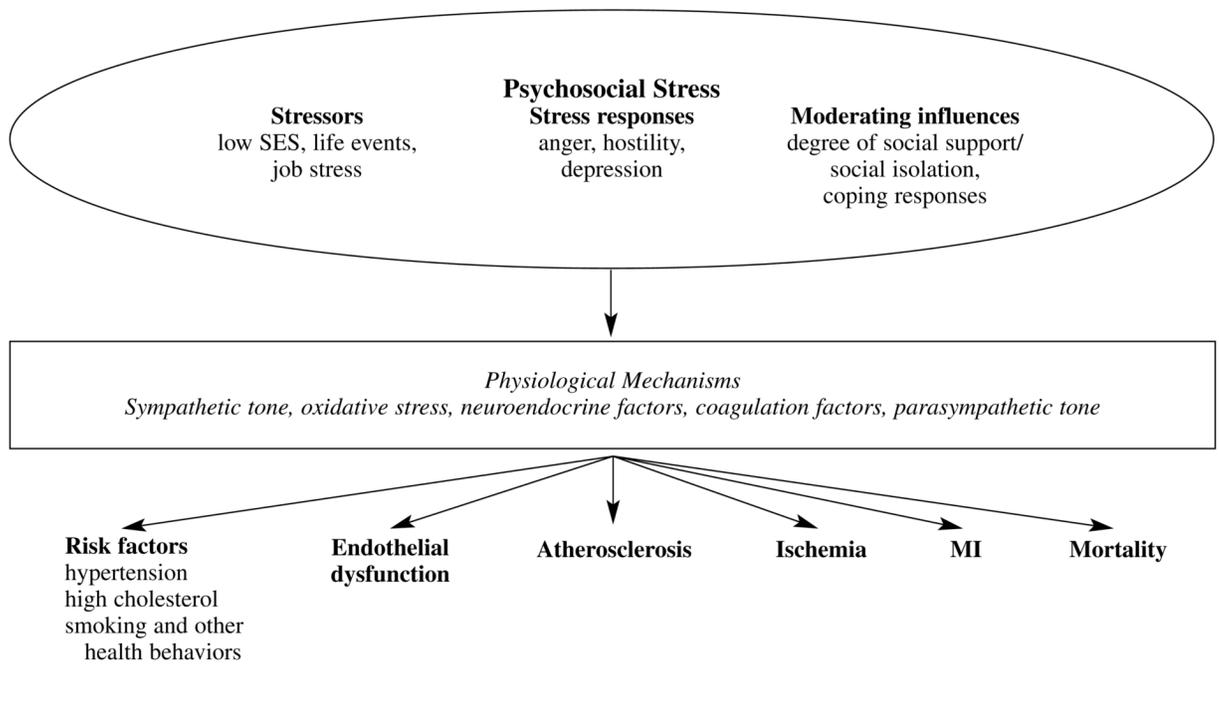
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Note. SES = socioeconomic status; MI = myocardial infarction.

**FIGURE 1.**  
Behavioral model of psychosocial stress and cardiovascular disease.

TABLE 1

Controlled Research on Effects of the *Transcendental Meditation (TM)* Program on Risk Factors for CVD, 1987–2002

Citation, field location, design	Participants	Intervention	Follow-up period	Measure	Result
Alexander et al, 1989 <sup>32</sup> Boston, MA RCT	Residents of homes for the elderly, $M = 81$ y ( $N = 73$ ) 78% women	TM ( $n = 20$ ); MT ( $n = 21$ ); MR ( $n = 21$ ); no treatment control ( $n = 11$ , 22 for survival)	High BP 3 mo for most variables 36 mo for survival	SBP, survival, and TM reduced SBP more than did MT, MR, and C (contrast coefficients of 3, 1, -2, and -2, respectively, $p < .01$ ); similar other health-related variables; results obtained with survival rates, mental health, paired associate learning, 2 measures of cognitive flexibility and functioning, 2 measures of behavioral flexibility, aging, and treatment efficacy ratings of personal flexibility, aging, and treatment efficacy; personality, and self-report measures, regularity of practice	Compared with HE controls, TM reduced SBP by 11 mm Hg, and DBP by 6 mm Hg ( $p < .0003$ and $.00005$ , respectively); compared with PMR, TM reduced both SBP and DBP by 6 mm Hg ( $p < .02$ & $.03$ , respectively); linear trend analysis for PMR
Schneider et al, 1995 <sup>30</sup> Oakland, CA RCT	Inner-city older African Americans with hypertension ( $N = 127$ )	TM ( $n = 36$ ); progressive muscle relaxation (PMR, $n = 37$ ); health education controls (EC, $n = 38$ )	3 mo	BP changes from baseline to final follow-up, measured by mm Hg ( $p < .02$ & $.03$ , respectively); linear trend analysis for PMR	Compared with HE controls, TM reduced SBP by 11 mm Hg, and DBP by 6 mm Hg ( $p < .0003$ and $.00005$ , respectively); compared with PMR, TM reduced both SBP and DBP by 6 mm Hg ( $p < .02$ & $.03$ , respectively); linear trend analysis for PMR
Alexander et al, 1996 <sup>31</sup> Oakland, CA RCT	Inner-city older African Americans with hypertension ( $N = 127$ )	TM ( $n = 22$ women, 19 men) (PMR, $n = 22$ women, 20 men) HE controls ( $n = 30$ women, 14 men)	3 mo	Subgroup analysis of BP changes in women (10) and men (13 mm Hg, $p < .01$ ) and DBP in women (6 mm Hg, $p < .01$ ) and men (8 mm Hg, $p < .001$ ); TM significantly reduced SBP and DBP in all risk subgroups sex and by high and low risk on: psychosocial stress, obesity, alcohol use, physical inactivity, sodium-potassium ratio, and a composite measure	Compared with HE controls, TM reduced SBP in women (10 mm Hg, $p < .01$ ) and in men (13 mm Hg, $p < .01$ ) and DBP in women (6 mm Hg, $p < .01$ ) and men (8 mm Hg, $p < .001$ ); TM significantly reduced SBP and DBP in all risk subgroups sex and by high and low risk on: psychosocial stress, obesity, alcohol use, physical inactivity, sodium-potassium ratio, and a composite measure
Wenneberg et al, 1997 <sup>33</sup> Iowa City, IA RCT	Young 18 y–34 y normotensive American males ( $N = 39$ )	White TM ( $n = 20$ ); Education control ( $n = 19$ )	4 mo	Ambulatory BP from 1300 hours to 2200 hours on 1 day	Compared with controls, TM decreased ambulatory BP by 9 mm Hg in the high-compliance subgroup ( $p = .04$ )
Barnes et al, 2001 <sup>34</sup> Augusta, GA RCT	Adolescents with high normal BP ( $N = 35$ ); 34 African Americans and 1 White American	TM ( $n = 17$ ); Lifestyle education ( $n = 2$ )	3 mo	Resting BP; pretest demographics; stress responsiveness (see below)	TM reduced resting SBP (7.5 mm Hg, $p < .03$ ) relative to controls and reduced the stress responsiveness (see below)
De Armond, 1996 <sup>35</sup> Kansas City, MO CS	Managers and executives of a medical equipment developer and manufacturer ( $N = 76$ )	TM ( $n = 38$ ) vs no-treatment controls matched for company rank ( $n = 38$ )	Lipids and Cholesterol 3 mo	Fasting total cholesterol, BP, self-reported stress measures, observer-reported stress measures	TM significantly reduced total cholesterol relative to controls ( $p = .03$ ) and improved self-reported and observer-reported stress measures ( $p < .002$ – $.05$ )

Citation, field location, design	Participants	Intervention	Follow-up period	Measure	Result
Schneider et al, 1998 <sup>56</sup> Fairfield, IA OS	Older, normally healthy, community-dwelling volunteers, age range 56 to 74 y, $M = 67$ ( $N = 41$ )	Long-term (average age 16.5 y) practitioners of TM ( $n = 18$ ) vs age-, sex-, and education-matched nonpractitioner controls ( $n = 23$ )	NA	Lipid peroxides in TM group serum; intakes of fat, vitamins, red meat; level of cigarette use	15% lower in lipid peroxides ( $p = .026$ ) and consumed less red meat ( $p < .001$ )
Calderon, 2000 <sup>37</sup> Los Angeles, CA RCT	African American adults with mild or medication-controlled hypertension ( $N = 66$ )	TM ( $n = 34$ ) vs HE mean cholesterol was 213 mg/dL	6 mo	Fasting cholesterol (total, LDL, HDL) and triglycerides; pretest demographics; diet, exercise, and physiologic measures	No significant effects of TM on any cholesterol or lipid variable when compared with controls by ANCOVA; controls improved significantly more on intake of total fat, cholesterol (trend), fiber, saturated fat, % calories from fat, % calories from sweets, total caloric intake
Alexander et al, 1994 <sup>38</sup> Various locations, USA & abroad QMA, controlling for strength of study design	19 TM studies; adolescents, college students, working adults, elderly African Americans, criminal offenders, Vietnam veterans, and skid-row alcoholics ( $N = 4,524$ )	TM practice vs mixed controls, no-treatment, some active treatment	9.7 mo average	Use of alcohol, cigarettes, and illicit drugs	Compared with controls, TM effect sizes were alcohol use, $.55$ ( $p = .0008$ ); cigarette use, $.87$ ( $p = .00003$ ); illicit drug use, $.83$ ( $p = .000005$ )
Wenneberg et al, 1997 <sup>33</sup> Iowa City, IA RCT	Young (ages 18–34 y) normotensive White American males ( $N = 39$ )	TM ( $n = 20$ ); Education control ( $n = 19$ )	4 mo	Stress reactivity of BP and heart rate to 3 laboratory stressors and a simulated public speaking test	Compared with controls, TM did not affect BP or heart rate reactivity to mental arithmetic, mirror image tracing, or isometric handgrip, but increased SBP reactivity to public speaking stress in the high compliance participants ( $p = .06$ ).
Barnes et al, 2001 <sup>34</sup> Augusta, GA RCT	Adolescents with high normal BP ( $N = 35$ ); 34 African Americans and 1 White American	TM ( $n = 17$ ); Lifestyle education ( $n = 18$ )	2 mo	Stress responsiveness of BP, heart rate, cardiac output, and peripheral resistance; pretest demographics	Compared with controls, TM reduced the stress responsiveness of: SBP (9 mmHg, $p < .03$ ), cardiac output ( $p < .01$ ), heart rate ( $p < .03$ ), and DBP ( $p < .07$ )

*Note.* RCT = randomized controlled trial; OS = observational study; QMA = quantitative meta-analysis; CS = controlled study; BP = blood pressure; SBP = systolic blood pressure; DBP = diastolic blood pressure; PMR = progressive muscle relaxation; HE = health education; MT = mindfulness training; MR = mental relaxation; C = control; LDL = low-density lipoprotein; HDL = high-density lipoprotein; NA = not applicable; OM = other meditation; OR = other relaxation; PR = progressive relaxation.

Controlled Research on the Ability of the *Transcendental Meditation (TM)* Program to Change Psychologic Indicators or Consequences of Stress, 1987–2002

Citation, field location, design	Participants	Intervention	Follow-up period	Measure	Result
Eppley et al, 1989 <sup>47</sup> Various locations in USA & abroad QMA, controlling for strength of design, experimenter bias, pretest demographics, pretest anxiety	All studies (146 independent outcomes) of meditation and relaxation on trait anxiety	TM (35 outcomes), other meditation (OM), (mo) TM = 2.5, OM = 44 outcomes), progressive relaxation 1.4 (PR, 30 outcomes) and other relaxation (OR, 37 outcomes)	Avg intervention 1.8, PR = 1.6, OR = 1.4	Scores on standardized instruments measuring for PR (.38, $p < .005$ ), and for OR (.40, $p < .005$ )	Mean effect size for TM (.70) was larger than for OM (.28, $p < .001$ ), and for OR (.40, $p < .005$ )
Gaylord et al, 1989 <sup>48</sup> Pine Bluff, AR RCT	African American volunteers, mostly college students ( $N = 83$ )	TM ( $n = 25$ ), PMR ( $n = 29$ ), cognitive-based self-improvement (CS, $n = 29$ )	1 y	Measures of mental health, anxiety, neuroticism, and electrophysiological variables, including habituation of the skin potential response to a noxious sound	TM ( $p = .02$ ) and PMR ( $p = .04$ ) each increased a general mental health factor, compared with CS, with state anxiety and neuroticism the most improved; TM shortened the time to habituation of skin potential response, compared with CS
Alexander et al, 1991 <sup>49</sup> Various locations in USA & abroad QMA, controlling for duration of treatment and strength of experimental design	All studies (42 treatment outcomes) on effects of TM on self-actualization, a measure of psychological health	TM (18 independent outcomes), assorted comparison groups (24 outcomes)	5 wk–3.5 y	Scores on Shostrom's Personal Orientation Inventory (14 studies) or alternate instruments (4 studies); factor analysis gave 3 factors: "affective maturity," "integrative perspective on self and world," and "resilient sense of self"	Effect size for TM was .78, which was 3 times the size for other forms of meditation (.26) and for relaxation techniques (.27) ( $p < .0002$ ); individual factors also showed 3-fold greater change in the TM group ( $p < .0001$ , .005, .005, respectively)
Ferguson, 1991 <sup>50</sup> Various locations in USA & abroad QMA, controlling for setting and strength of design	51 studies with 404 independent outcomes ( $N = 9,470$ )	TM effects (160 outcomes) compared with effects of other meditation and relaxation techniques	9.7 mo (avg)	All affective measures (eg, anxiety, self-concept, etc) were included	TM effect size (.62 or .70) was more than 2 times the size of comparison groups, regardless of experimental design used
Alexander et al, 1994 <sup>38</sup> (see details under Tobacco and Other Substance Abuse, T-1) Various locations in USA & abroad QMA	14 studies on abusers of alcohol or other substances that also examined the decrease of negative psychological outcomes; 10 studies on abusers that also examined increases in positive psychological outcomes	TM practice vs mixed controls (some no-treatment, some active treatment)	10 mo (avg)	Decrease of negative psychological outcomes (eg, depression, anger, hostility, and anxiety); increase of positive psychological outcomes (eg, self-concept, internal locus of control)	TM reduced negative psychological outcomes relative to controls, with effect size of .64; TM increased positive psychological outcomes, with effect size of .51 ( $p = 2 \times 10^{-6}$ )

Note. See note in Table 1 for abbreviations used in these studies.

Controlled Research on the Ability of the *Transcendental Meditation (TM)* Program to Change Physiologic Indicators or Consequences of Stress, 1987–2002

Citation, field location, design	Participants	Intervention	Follow-up period	Measure	Result
Dillbeck & Orme-Johnson, 1987 <sup>52</sup> Various locations in USA & abroad QMA	31 studies, normal adult populations	Acute and longitudinal effects of TM vs eyes-closed rest; the meta-analysis for each variable had at least 5 studies on TM and at least 3 on eyes-closed rest	NA	Basal skin resistance, skin resistance responses, respiratory rate, heart rate, and plasma lactate levels	The TM session had larger effects on basal skin resistance ( $p < .05$ ), respiratory rate ( $p < .05$ ), and plasma lactate ( $p < .01$ ); significant pretest differences on 4 of the 5 variables ( $p < .01 - p < .05$ )
Gaylord et al, 1989 (See previous listing, Table 2.) Mills et al, 1990 <sup>54</sup> Fairfield, IA CS	Normally healthy, nonobese volunteers ( $N = 20$ , age $M = 31$ ) ( $n = 10$ ) and age-matched male controls ( $n = 10$ ) who practiced no behavioral technique	Long-term (9 y) male practitioners of TM	NA	Beta-adrenergic receptors, binding affinity, plasma NE and E, Type A behavior, exercise, and family history of high BP	TM group higher on high-affinity beta-adrenergic receptors ( $p = .009$ ), but groups did not differ on total beta receptors, binding affinity, plasma NE and E, Type A behavior, exercise, or family history of hypertension
Alexander et al, 1993 <sup>55</sup> Midwest, USA CS	Normally healthy workers at separate sites in the automotive industry ( $N = 86$ )	2TM group ( $n = 45$ ), controls matched by worksite, job position, and demographic characteristics ( $n = 41$ )	3 mo	Skin resistance, psychological indicators of stress, job tension, and job satisfaction, employee effectiveness, work/personal relationships, cigarette and hard liquor use	Regular practice of TM significantly improved scores in all areas of measurement, compared with controls; irregular practice of TM produced changes intermediate between the regular practice group and controls
Walton et al, 1995 <sup>56</sup> Fairfield & Cedar Falls, IA CS	Normally healthy volunteers ( $N = 55$ , age $M = 29$ y)	Long-term (8.5 years) practitioners of TM ( $n = 22$ ) and age-matched controls ( $n = 33$ ) who practiced no stylized technique for stress reduction	TMNA	Self-report instruments and urinary indicators of chronic stress, POMS, STAI, and cortisol, aldosterone, SHIAA, VMIA, DHEAS, and the ions of Na, K, Ca, Mg, and Zn	TM group was lower on mood disturbance and anxiety ( $p < .01$ and $p = .05$ , respectively) and also on excretion of cortisol ( $p = .002$ ), VMIA urinary indicators ( $p < .001$ ), aldosterone ( $p = .04$ ), and electrolytes (except Mg, K; of chronic stress, $p < .001$ to $.02$ ) and higher on excretion of SHIAA ( $p < .01$ ), and specifically: DHEAS ( $p < .01$ ), all consistent with lower levels of stress
Levitsky, 1997 <sup>57</sup> Iowa City, IA RCS	Healthy male volunteers ( $N = 49$ , age range = 18–32 y)	Randomly assigned participants completing posttests (TM, $n = 16$ ; control, $n = 19$ )	4 mo	Changes in urinary indicators of chronic stress, SHIAA excretion rates of cortisol, aldosterone, SHIAA, DHEAS, and the ions of Na, K, Ca, Mg, and Zn	TM significantly reduced cortisol excretion ( $p = .001$ , within-group) and electrolyte excretion ( $p < .05$ , between-group), and increased SHIAA excretion ( $p = .03$ , within-group), consistent with a reversal of effects of chronic stress
MacLean et al, 1997 <sup>58</sup> Iowa City, IA RCS	Healthy male volunteers ( $N = 49$ , age range = 18–32 y)	Randomly assigned participants completing posttests (TM, $n = 16$ ; control, $n = 13$ )	4 mo	Plasma levels of cortisol, TSH, GH, and testosterone	TM reduced baseline cortisol ( $p = .04$ ) and avg. cortisol ( $p = .04$ ), increased cortisol response to stress ( $p = .02$ ), and affected TSH, GH, and testosterone in a manner opposite to effects of stress.

Citation, field location, design	Participants	Intervention	Follow-up period	Measure	Result
Infante et al, 1998 <sup>59</sup> Granada, Spain CS	Healthy volunteers (TM group) vs controls, N = 27	Seasoned TM practitioners (n = 18) compared with nonpractitioner controls (n = 9)	NA	Plasma levels of cortisol, beta-endorphin, and ACTH at 0900 and 2000 h	TM group showed no diurnal rhythm in beta-endorphin and ACTH; a change in feedback sensitivity is suggested
Infante et al, 2001 <sup>60</sup> Cordoba, Spain CS	Healthy volunteers (TM group) vs controls, N = 35	Seasoned TM practitioners (n = 19) compared with nonpractitioner controls (n = 16)	NA	Plasma levels of catecholamines (NE, E, and DA) at 0900 and 2000 (morning E: TM = 140, control = 120, p = .02)	Morning and evening NE and morning E were significantly lower in the TM group (morning NE, pg/mL: TM = 137, control = 237, p = .0001); (evening NE: TM = 120, control = 176, p = .009);
Barnes et al, 1999 <sup>61</sup> Augusta, GA CS	Healthy, normotensive men and women (M age = 46 y, N = 32)	Long-term (22 y) practitioners of the TM program (n = 18), compared with nonpractitioner controls (n = 14)	<i>Hemodynamics</i>	Hemodynamic variables were assessed before and during 2 periods: 20 min of eyes-open rest (both groups), 20 min of TM (TM group) or eyes-closed rest (control group)	During eyes-open rest and during TM or eyes-closed rest, the TM group significantly decreased SBP and total peripheral resistance and increased in cardiac output, relative to the control group (p < .004 to p < .04)

Note. Abbreviations used are the same as those in Table 1, plus NE (norepinephrine), E (epinephrine), DA (dopamine), ACTH (adrenocorticotrophic hormone), TSH (thyroid stimulating hormone), GH (growth hormone), 5HIAA (5-hydroxyindoleacetic acid), VMA (vanillylmandelic acid), DHEAS (dehydroepiandrosterone sulfate).

TABLE 4

Controlled Research on the Effects of the *Transcendental Meditation (TM)* Program on CVD Morbidity and Mortality, 1987–2002

Citation, field location, design	Participants	Intervention	Follow-up period	Measure	Result
Castillo-Richmond et al, 2000 <sup>63</sup> Los Angeles, CA RCT	African American adults with hypertension (avg age 54 y, N = 60)	TM (n = 31); health education control (n = 29)	7.5 mo	Mean carotid IMT across 6 sites; secondary outcomes: BP, total, HDL-, and LDL-cholesterol, exercise, weight, smoking, and other variables	TM reduced carotid IMT by .15 mm (10%) relative to controls (p = .04); no significant differences between sites; secondary outcomes on other variables, although within-group outcomes: BP, decreases in BP were significant
Fields et al, 2002 <sup>64</sup> Chicago, IL RCT	Normally healthy older White Americans (avg age 74 y, N = 46)	TM (along with Vedic diet, exercises, herbal supplements; n = 20); modern diet (exercise, multivitamins; n = 9); usual care only (n = 14)	12 mo	Mean carotid IMT across 6 sites; secondary outcomes: BP, cholesterol and lipids, serum glucose, weight, BMI, and other variables	TM (with other Vedic approaches) reduced carotid IMT in a higher fraction of participants than did the modern sites; secondary treatment and usual care combined (p < .05); in a high-risk subgroup, TM reduced IMT by .34 mm (20%, p = .009) compared with usual care
Kondwani, 1998 <sup>66</sup> Oakland, CA RCT	African American adults with hypertension (N = 42)	TM (n = 22); health education controls matched on medication, gender, BP range (n = 20)	12 mo	LVMi, BP, vitality, affect, behavioral/emotional control, sleep dysfunction, anxiety, and depression	Both TM and HE reduced LVMi (> 10%, p < .01), but only TM produced significant improvements in DBP and in most other measures
Zamara et al, 1996 <sup>67</sup> Buffalo, NY RCT	Patients with documented coronary artery disease (N = 21)	TM (n = 12) vs waitlisted controls (n = 9)	7.6 mo	Symptom-limited exercise tolerance tests after an overnight fast	TM significantly reduced exercise-induced ischemia, and increased exercise tolerance, maximum workload, and delay of onset of ST segment depression, relative to controls
Alexander et al, 1989 <sup>32</sup> Boston, MA RCT	Residents of homes for elderly (M age = 81, N = 84); 78% women	TM (n = 20); mindfulness training (MT, n = 21); mental relaxation (MR, n = 21); treatment control (C, n = 22)	36 mo	Survival (and other health-related variables; see Table 1 under High Blood Pressure)	TM group showed 100% survival, compared with 87% for MT, 65% for MR, 77% for C & 62.6% for all those in the same institutions who were not assigned to groups, p < .00025

Note. Abbreviations used are the same as those in Tables 1 to 3, plus IMT = intima-media thickness; BMI = body mass index; LVMi = left ventricular mass index.