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Behavioral Treatment of Hypertensive Heart Disease in African Americans: Rationale and Design of a Randomized Controlled Trial

Robert H. Schneider, MD; Amparo Castillo–Richmond, MD; Charles N. Alexander, PhD; Hector Myers, PhD; Vidya Kaushik, MD; Cesar Aranguri, MD; Keith Norris, MD; Chinelo Haney; Maxwell Rainforth, MS; Raul Calderon, PhD; Sanford Nidich, EdD

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African Americans experience higher morbidity and mortality than Whites do as a result of hypertension and associated cardiovascular disease. Chronic psychosocial stress has been considered an important contributing factor to these high rates. The authors describe the rationale and design for a planned randomized controlled trial comparing Transcendental Meditation, a stress-reduction technique, with lifestyle education in the treatment of hypertension and hypertensive heart disease in urban African Americans. They pretested 170 men and women aged 20 to 70 years over a 3-session baseline period, with posttests at 6 months. Outcomes included clinic and ambulatory blood pressure, quality of life, left ventricular mass measured by M-mode echocardiography, left ventricular diastolic function measured by Doppler, and carotid atherosclerosis measured by ß-mode ultrasound. This trial was designed to evaluate the hypothesis that a selected stress reduction technique is effective in reducing hypertension and hypertensive heart disease in African Americans.

Index Terms: *clinical trial, hypertension, left ventricular hypertrophy, stress reduction, Transcendental Meditation*

Despite advances in modern medical and surgical interventions, coronary heart disease (CHD) remains the number one cause of mortality, disability, and healthcare costs in the United States.[1] Hypertension and hypertensive heart disease are major contributors to mortality rates, and African Americans are particularly affected by these health problems,[1] which are largely attributable to modifiable, behavior-related factors, including psychosocial stress, that can be prevented at substantially lower costs to the individual and society.[2] In this article, we review the literature and describe the protocol for a planned clinical trial using Transcendental Meditation (TM), a stress-reduction program, as a behavioral intervention for the treatment of hypertension and hypertensive heart disease in African Americans.

Epidemiology of Hypertensive Heart Disease in African Americans

The health disadvantages that African American men and women of all ages[3,4] experienced throughout the last 100 years are reflected in mortality rates that are about 50% higher than the rates for White Americans.[5] More than 30% of this excess mortality is a result of cardiovascular disease (CVD)[6] that becomes clinically manifest an average of 5 years earlier and has significantly greater mortality among African Americans than among Whites of the same age (at least through age 64 years for men and age 74 for women).[7]

For the past 3 decades, the Black/White ratio of CHD deaths has steadily increased,[8] but the recent declines in the

US age–adjusted CHD death rate are significantly less for African Americans than for Whites.[4]

From 40% to 60% of the CHD mortality risk in African Americans is attributable to the prevalence and severity of hypertension, which is recognized as the greatest contributor to excess heart disease.[9] Hypertension is not only more prevalent in African Americans than in White Americans, but has an earlier onset, is more severe, goes untreated longer, rises more rapidly with age, and is associated with greater target organ dysfunction.[9,10] African Americans have demonstrated greater sympathetic hyperactivity, a factor in the etiology of hypertension, in response to physical and psychological stresses.[11]

Delayed treatment for hypertension among African Americans leads to hypertension mortality rates 5 to 7 times those of White Americans.[9] A number of cardiovascular risk factors (eg, hypertension, obesity, serum lipid levels, and smoking) are interrelated in their etiology and contribute individually and in combination to high levels of CHD morbidity and mortality.[12,13] These risk factors are also powerfully influenced by behavioral interventions.

Psychosocial Stress, Hypertension, and Hypertensive Heart Disease in African Americans

Study findings suggest that psychosocial stress may play an important role in the higher incidence of CVD among Black Americans.[3,11,14,15] Socioecological conditions, social disorganization, limited resources and social support, rural–urban migration, social–familial situations, and socioeconomic status are among the potential components of stress in this group. These stressors also increase the risk for unhealthy lifestyles that may lead to higher clinical CVD.[16] African Americans' psychosocial stress has been postulated as an explanation for the observed negative correlation of socioeconomic status with CVD morbidity and mortality.[16]

Occupational and environmental stressors are also believed to be linked to chronically high levels of autonomic arousal.[17,18] Chronic socioenvironmental and psychosocial stress may result in chronic psychophysiological arousal, increased sympathetic tone, cardiovascular reactivity, and peripheral vasoconstriction among African Americans. In turn, renally mediated sodium retention may predispose this ethnic population to hypertension.[11,15,19] High levels of anger and suppressed hostility have also been associated with elevated ambulatory and home blood pressure (BP) in Blacks.[20,21] The National Health and Nutrition Epidemiologic Follow-Up Survey (NHNES) found associations between anxiety and the development of hypertension.[22,23]

Quality of life for Black adults is especially susceptible to "multiple jeopardy" because of the negative effects of socioeconomic stressors, combined with the deleterious effects of aging itself.[24] Despite these findings, comparisons of different stress-reduction therapies for treating hypertension and enhancing quality of life in adult Blacks have been rare.[8] Studies of the effects of stress reduction on left ventricular hypertrophy (LVH) or other cardiovascular markers are equally hard to find.

Left Ventricular Hypertrophy

The main structural change of the heart in hypertension is in the left ventricular mass (LVM), where incremental changes are directly associated with increased BP.[25] Patients with mild-to-moderate hypertension have been shown to have a 20% to 60% prevalence of LVH.[26,27] LVM is also a stronger predictor of target organ damage than ambulatory or clinic BP in hypertensive individuals;[28] it has been proposed as an intermediate point in determining prognosis of hypertensive disease and assessing the effectiveness of therapeutic interventions.[29]

Hemodynamic factors such as BP, contractility, cardiac output, valvular disease, blood viscosity, and nonhemodynamic factors (eg, diet, weight, age, renal disease, and hormonal differences) appear to account for the development of LVH.[8,26,30] Exercise also induces hypertrophy, thus creating a confounding factor in the relation between hypertension and hypertrophy in young people.[31]

Although race does not seem to influence LVM assessed by echocardiography in Blacks,[32,33] increased relative and interventricular wall thickness unexplained by racial differences in resting and ambulatory BP has been found in African Americans.[32–34]

New electrocardiographic algorithms for detecting LVH in adults are showing promising results in finding gender,[35] age,[36] and pathophysiological distinctions, but few assessments have been conducted in various ethnic groups.[37,38] The Sokolow-Lyon and Cornell voltage-duration product criteria are differently related to adverse risk factors, with the former predominantly associated with Blacks.[39] The

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Atherosclerosis Risk in Communities study (ARIC), a population-based cohort evaluation in African Americans, used computer measurements in electrocardiography.[40] That study, which used pulse pressure as a measure of arterial compliance, found significantly higher levels of LV mass in Blacks than in Whites and an increased relation between pulse pressure and LV mass.[40]

The Coronary Artery Risk Development in Young Adults (CARDIA) study, which used M-mode echocardiography, found that LVM is correlated with systolic BP and body weight in Black and White cohorts. That study also found a 5 to 11 gram higher LVM in Black women and men, respectively, compared with Whites.[41]

LVH is an independent risk factor for coronary artery disease, sudden death, ventricular arrhythmia, myocardial ischemia, and congestive heart failure; it is also an important predictor of cardiovascular morbidity and general mortality.[25,26,42] The effect of LVH has been found to be similar in patients with and without CHD.[43,44] In addition, LVH, primarily resulting from hypertension, is approximately twice as prevalent in African Americans as it is in Whites. It is found in half of African American patients with CHD, and has been considered responsible for much of the Black–White differential in CHD mortality.[45] The development of hypertensive LVH in African Americans is associated with depression of endothelial-dependent and endothelial-independent coronary vascular relaxation,[46] with reductions in coronary flow reserve and perfusion defects.[47] A recent study has demonstrated that LVH is a stronger risk factor than hypertension, cigarette smoking, and hypercholesterolemia, and is associated with a greater relative and attributable risk than all of the traditional measures of CAD severity.[45] This high prevalence and powerful risk of LVH make an important contribution to the adverse survival rates among Black patients with heart disease.[48,49]

Diastolic Dysfunction

Hypertension, even in its early stages and in the absence of hypertrophy, produces abnormalities in diastolic function.[50–52] Increased BP imposes an elevated after-load that influences relaxation and impairs ventricular filling, independent of LV mass.[53] These abnormalities can be found in borderline and isolated systolic hypertension in advance of the development of LVH or systolic dysfunction.[50] The inverse relationship of early filling (curve E) to age and diastolic blood pressure found in normal individuals disappears in hypertensive patients. At the same time, the increase of atrial filling (curve A) found in hypertensive persons resembles that produced by age and is considered to reflect a reduction in chamber compliance.[53] These findings highlight the effect of hypertension in the aging process in cardiovascular structures. Improvement in diastolic function is clearly observed with reduction of blood pressure levels in borderline and mildly hypertensive patients after 6 months of pharmacologic treatment.[54,55] In general, most findings on ventricular dysfunction have come from pharmacologic studies of hypertension, whereas evaluations of the impact of stress management and nutritional–hygienic therapies on diastolic function are generally overlooked.

Carotid Atherosclerosis

Hypertension is a predictor of asymptomatic carotid artery disease in all age groups over 40 years;[56] it is associated with increased prevalence of atherosclerosis in carotid arteries.[57] Hypertension increases the stiffness and thickness of the intima-media (IM) complex of the carotid wall, facilitating the development of the atheromatous plaque.[56,57] Intima-medial thickness (IMT) as a measure of carotid artery disease is positively correlated with hypertension.[26,58] Carotid atherosclerosis is correlated with coronary atherosclerosis independent of other risk factors,[59] and carotid IMT is a significant predictor of coronary outcomes.[60] Adaptive changes to hypertension are expressed as similar patterns of transformation in arteries and ventricles. Peripheral atherosclerosis is correlated with LVH and with increased variability of 24–hour BP.[61] In hypertensive patients, atherosclerosis is associated with cardiac and vascular hypertrophy,[62] and arterial rigidity is correlated with LV geometry in both normotensive and hypertensive patients.[63,64]

Acute and chronic psychological stress in African Americans contributes to the development of atherosclerosis by (a) increasing free fatty acids or serum chloresterol[65] and low-density lipoprotein peroxidation[66] and by (b) favoring hemodynamic changes that affect cardiovascular reactivity and arterial compliance.[18,67,68] Psychological stress and higher cholesterol levels are also implicated in the development of hypertension[69] and atherosclerosis.[70] Stress reduction programs that use the Transcendental Meditation (TM) technique have been reported as significantly lowering total cholesterol,[71] lipid peroxide levels,[72] and carotid artery IM thickness.[73]

Treatments for Hypertension and Cardiovascular Disease in African Americans

The Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VI) discusses two major approaches to antihypertensive therapy: lifestyle modification and pharmacological treatment.[74] The first approach includes reducing weight, increasing physical activity, stopping smoking,

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reducing alcohol intake, improving diet management (in terms of sodium, carbohydrates, fat, caffeine), using dietary supplements (potassium, calcium, and magnesium), and reducing stress. The second approach recommends consuming a vast array of antihypertensive agents, depending on the severity of the problem and concomitant diseases.

Pharmacologic Therapies

The incidence of CVD and mortality decreases from using drug therapy, but these markers are still significantly higher in hypertensive individuals than in those with BP that is naturally in the normotensive range.[75] Protection against stroke has been demonstrated, but the results were found to be less than optimal when CHD was considered.[74,75] Although ß-blockers and diuretics have demonstrated reduced cardiovascular morbidity and mortality in long-term controlled trials,[74] calcium channel blockers do not seem to have the same positive effect.[76] The Captopril Prevention Program (CAPPP), the first trial comparing angiotensin-converting enzyme (ACE) inhibitors with older classes of antihypertensive drugs, reported that Captopril was as effective as diuretics or ß-blockers in reducing cardiovascular events, although it was also associated with increased risk of stroke.[77] Newer medications (eg, angiotensin receptor blockers) still need to be evaluated in long-term controlled clinical trials for their effects on cardiovascular morbidity and mortality.[74]

Regression of LVH in hypertension occurs differently with various medications. Vasodilators are associated with attenuated regression or even progression of hypertrophy,[78] and beta-blockers produce significant regression.[78] Diuretics may produce significant LVM reduction,[79] with long-term residual effect after the patient stops using the medication.[80] Published studies report that diuretics and ß-blockers, compared with ACE inhibitors and calcium channel blockers, are the least potent medications.[81] Yet, meta-analyses show that ß–blockers and calcium-channel blockers seem to have comparable effects, whereas ACE inhibitors exhibit greater ability to reduce LV mass. Randomized clinical studies of the effects of angiotensin receptor blockers on LVH have not been reported.

Adverse side effects of drug treatment or interactions with pharmacologic therapy for concurrent conditions affect the quality of life of hypertensive patients.[82] Financial considerations may also limit compliance and hence, the efficacy of any sound and well-planned antihypertensive drug treatment. In Black populations, high levels of noncompliance represent a major obstacle to effective treatment.[83] The assessment of treatment success for hypertensive heart disease should include the effects on blood pressure and on a wide range of other physiological functions and quality-of-life measures that can be adversely affected by conventional drug treatments.[84]

Lifestyle Modification and Stress Reduction

Because of the etiologic associations of psychophysiological stress, high BP, and LVH, stress reduction may be useful as an adjunct to regular care in treating hypertensive heart disease in African Americans. The JNC VI recognizes the use of behavioral therapies for treating mild hypertension and recommends that it be used alone or together with drug therapy. Those authors, however, consider the use of stress-management techniques uncertain and do not include them among their recommended lifestyle modifications for preventing and managing hypertension.[74] The authors of the JNC VI and some other researchers assume that all stress-reduction techniques are the same and have similar effects on BP. On the other hand, meta-analyses comparing all available data on different approaches to stress reduction have reported that the TM program has a significant influence on several cardiovascular risk factors, including hypertension, smoking, alcohol consumption, and negative affect (anger, hostility and anxiety), and is more effective than progressive muscle relaxation (PMR) in reducing BP levels.[85–87]

In studies on the regression of LVH with lifestyle modification, researchers have reported that obese patients who lost 8 kilograms of weight showed a reduction in LVM greater than controls who were treated with metoprolol.[88] Nonpharmacologic treatment with sodium restriction in mild-to-moderate hypertensive patients also showed positive results in reducing LV mass.[89] The Treatment of Mild Hypertension Study (TOMHS) used nutritional hygienic intervention alone[33,90] and found a reduction of 9.1 SBP/8.6 DBP mm Hg in persons with mild hypertension. These studies, however, do not address the needs of African Americans, nor can their results be extrapolated to that population.

Transcendental Meditation (TM)

The TM program, taught worldwide by Maharishi Mahesh Yogi for more than 40 years,[91] is the main program for stress reduction in the Maharishi Vedic approach to health, a traditional system of natural and prevention-oriented healthcare derived from ancient Vedic traditions.[92] It is a mental procedure that people practice for 20 minutes twice a day as they sit comfortably with eyes closed. During this time, the ordinary thinking process is said to become calm and the individual experiences a psychophysiological state of "restful alertness."[93,94] In published studies, researchers have reported that persons who practice TM experience greater reductions in breathing rate and plasma

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lactate and increased basal galvanic skin resistance than they do when resting with their eyes closed.[95] Other reports include findings of lower cardiovascular reactivity and decreased adrenergic receptor sensitivity,[96] enhanced autonomic recovery to laboratory stressors,[97] and decreased plasma cortisol.[98] Acute increases in alpha EEG coherence across cortical areas and enhanced brain blood flow are said to distinguish TM from other forms of relaxation.[99,100]

The TM technique has been studied in many previous clinical trials and observational studies. Several meta-analyses have indicated that the effect of the TM technique on cardiovascular risk factors is larger than that produced by other relaxation programs.[85,95,101] TM has also been associated with good compliance, lower blood pressure, and enhanced quality of life in elderly White persons[102,103] as well as in elderly African Americans. Substantial effect sizes have been reported for reduction of systolic and diastolic BP in both medicated and nonmedicated individuals.[86,87] Bauwens et al[104] reported that aldosterone levels were significantly correlated with LVM, and Walton et al noted that TM practitioners have demonstrated lower aldosterone levels in patients using the program.[105]

Reported effects of TM on quality of life include reductions of trait anxiety,[101] anger[106] and depression;[107] enhancement of self-actualization;[85] and improved self-development.[108] Gaylord et al[109] found that urban Black adults practicing TM decreased in trait anxiety and neuroticism and increased on several aspects of self-concept compared with participants assigned to progressive relaxation or other self–improvement and control conditions. Alexander et al[87] also reported significant reductions in psychosocial stress markers in a group of elderly African Americans assigned to use the TM technique compared with those who participated in progressive muscle relaxation and health education programs.

The incidence of cardiovascular disease has been reported to be 50% lower in TM practitioners, with the largest effect on participants who were more than 40 years old.[110] A recent 6-year longitudinal study of medical costs of Canadian TM practitioners showed that the expenses of patients more than 50 years old and high users dropped more than 50% over a 3-year period, compared with a 3-year pre-TM baseline and a normative data base over the same period.[111] These health results are consistent with the finding of reduced cardiovascular and all cause mortality at 3,[103] 8, and 15 years[112] for the TM group, compared with results from usual care and other mental techniques combined in a randomized controlled trial in elderly White persons.

A study comparing health education with relaxation techniques demonstrated a significant effect of stress reduction in BP levels in African Americans.[86] That study compared mental (TM) and physical relaxation techniques (PMR) with health education. Both relaxation techniques were better than health education was in reducing stress, and the mental technique was twice as effective as the physical technique in reducing BP. The obtained average reduction in BP for the TM group was 10.7 mm SBP/6.4 DBP mm Hg.[86] The use of TM was reportedly effective in both men and women and in both high- and low-level cardiovascular risk and psychosocial stress.[87] We believe that the positive effect of this behavioral intervention on the health of the African American community represents a potential benefit to the general population.

METHOD

Objectives

Our primary objectives in conducting the present study were

- to investigate the effects of the TM technique compared with a heart disease education control group on reducing LVM and improving LV diastolic function
- to determine the relative effect of the TM stress-reduction program on BP, quality of life, psychosocial stress, known cardiovascular risk behaviors (eg, diet, exercise, smoking, weight, and alcohol consumption), and lipid levels
- to determine the interrelationships of changes in LV mass and function with observed changes in office BP, ambulatory blood pressure, psychosocial stress/quality-of-life factors, and cardiovascular risk factors

We invited patients undergoing echocardiography to participate in a simultaneous ancillary study on the effects of the TM technique on carotid atherosclerosis that used ß–mode ultrasound. Details of this study are described elsewhere.[73]

Study Design

This was a prospective, randomized, controlled trial comparing patients who used the TM technique with a control group who used heart disease education to treat hypertensive heart disease in African Americans. Participants were 170 male and female volunteers aged 20 to 75 years who had high normal, Stage 1 or Stage 2 hypertension. We recruited participants from urban Los Angeles through advertisements in local radio and TV programs and health-promoting events in the African American community. In addition, individuals from the community acted as recruiters, visiting health centers and community hospitals to invite people with a history of hypertension to participate in the study. During their initial clinic visit, all volunteers gave signed, informed consent and were informed that the study

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had been approved by Institutional Review Boards at Maharishi University of Management and Charles Drew Medical Center.

A baseline period of three visits included three blood pressure assessments, ambulatory BP monitoring, echocardiography and Doppler studies, ß-mode ultrasound of carotid arteries, testing for cardiovascular reactivity, psychological evaluations, and a cardiovascular risk-factor assessment. At the end of the baseline period, we averaged blood pressure recordings from the last two visits and used these and other factors to determine the eligibility of the individual for participation. Then we randomly assigned participants to one of the two treatment groups. In the randomization procedure, we matched subjects on age, gender, mean arterial pressure, medication status, and baseline LV mass.

Research staff members were blind to the treatment status of the participants, and both intervention groups were given the same information about anticipated benefits of the treatments.[86] After we took the baseline measurements, we regularly tested participants for clinic BP. We measured all other physiological and psychological variables at baseline and after 6 months' intervention.

Treatments

Transcendental Meditation Program

Participants' instruction in the TM program involved a five-step course of 1.5-hour meetings over 5 consecutive days, including an introductory discussion of the benefits and mechanics of the technique, a personal interview, a session of personal instruction, and follow-up in three small-group meetings. Follow-up refresher meetings were set up 1 week later, every 2 weeks for 2 months, and once a month for 3 months. A trained and certified local African American instructor familiar with the sociocultural backgrounds of the participants taught the TM course.

Cardiovascular Health Education

We decided to use a risk-factor prevention education program for the control group.[90,113] It included the nutritional and hygienic recommendations from the JNC VI, the Trials of Hypertension Prevention (TOHP), and the Trial of Mild Hypertension Study (TOMHS). This group received didactic instruction and group support for modifying the major cardiovascular risk factors through nonpharmacologic means. The instructor's background was similar to that of the TM program leader, but he was also qualified in cardiovascular risk reduction.

The intervention involved written materials and structured presentations based on other programs for African Americans in clinical studies.[86] We told participants about the importance of such risk factors as diet, salt consumption, weight, exercise, smoking, and drinking, and how to modify these behaviors to promote health and well-being.

The participants also learned about stress in an academic format, but the sessions did not involve practicing behavioral techniques. The heart disease education control group attended a 90-minute meeting once a week for the first 5 weeks, followed by a session every 2 weeks for 2 months, and, finally once a month for the last 3 months. Both groups participated in the same number of meetings.

Participant Selection

Inclusion Criteria

Eligible participants were (a) self-identified African Americans; (b) aged 21 to 70 years; (c) residents of Los Angeles or surrounding areas; (d) not taking antihypertensive drugs with Stage 1 or Stage 2 hypertension or taking antihypertensive therapy with high-normal levels of blood pressure (we defined Stage 1 hypertension as systolic BP of 140–150 mm Hg and/or diastolic BP of 90–99 mm Hg; stage 2 hypertension as systolic BP levels of 160–179 and diastolic BP of 100–109; and high-normal blood pressure as SBP of 130–140 and DBP of 85–89 mm Hg).[74] Individuals who met the above criteria underwent M-mode and Doppler echocardiography screening. Those chosen for participation were also eligible for ß-mode ultrasound of the carotid arteries. We referred those whose blood pressure exceeded 100 mm Hg diastolic or 160 mm Hg systolic for 2 consecutive months during the trial for standard care; they were allowed to continue in the study and are included in the final data analysis.

Exclusion Criteria

Reasons for exclusion from the study were (a) history of cardiovascular disease that required conventional treatment, such as stroke, transient cerebral ischemic attack (TIA), congestive heart failure, myocardial infarction, or angina pectoris; (b) significant EKG abnormalities such as major AV conduction defects, complete bundle branch blocks, or arrhythmias; (c) clinical evidence of functional incompetence related to a psychiatric condition or behavioral disorder such as alcoholism (> 28 drinks per week); (d) lack of informed or physician consent.

Physiological Measurements

Echocardiography

Echocardiography is the most common, specific, sensitive, and safe method for the serial assessment of LV mass.[114,115] M-mode echocardiography is useful in evaluating ventricular

structure, and Doppler echocardiography in assessing ventricular functional patterns.[116] We used the Penn criteria to obtain LV measurements at end-diastole and included measures of interventricular septal thickness (IVSTd), posterior wall thickness (PWTd), and left ventricular internal dimension (LVID). From the diastolic measurements, we calculated LV wall mass (LVM) according to the Penn equation[117] and LVM index according to body surface area and height.[118] We also calculated LV cross-section area, relative wall thickness, and LV diastolic dimension. We chose the Penn convention because of its high correlation to necropsy findings[117,119] and its use in previous clinical trials.[80,120]

Doppler

Doppler echocardiography offers a safe and reliable method of assessing cardiac functioning,[121] pathophysiological evolution,[55] and treatment effects in hypertensive patients with and without LVH.[51,53,55] It is used to evaluate diastolic performance measured by early diastolic flow and velocity of atrial contraction given by the ratio of early and late filling peaks.[116] Different studies use different indexes to evaluate diastolic function, but the most commonly used are peak velocity of early rapid filling phase (E), atrial contribution to late filling (A), and their ratio (E/A). These parameters present good intra- and interobserver reproducibility,[122] but intrasubject variability has been considered a confounding factor because studies have found dissimilar responses to pathological conditions. As a result, the recommendation is that each participant serve as his or her own control to allow the detection of small but statistically significant changes in diastolic function after an intervention.[123]

Psychological Measurements

The objective of psychological measurements is to assess the differential impact of the behavioral treatment on quality-of-life variables in patients with hypertensive heart disease. The patients' subjective perceptions of their own functional health is recognized as a critical medical outcome.[124] Perceived health status has been found to be a significant predictor of age-adjusted mortality rates in the general population over a 5-to-9-year period[125,126] and to physician use and costs in a largely minority Medicaid population.[127] We used the general recommendations of the Mild Hypertension Working Group and other researchers[128,129] to assess perceived physical and psychosocial functioning.

To assess physical functioning,[17] we used a controlled laboratory stress reactivity protocol adapted from the Recurrent Activation Model and the subscale of the Short Form Health Survey (SF–36) to measure general health perception.[130] We used a short form of the Mental Health Inventory with items for anxiety, depressed mood, and positive affect,[124] the Anger Expression Scale,[131] the Stress Impact Scale,[132] and the Perceived Stress Scale[133] to evaluate psychosocial functioning. In addition, we used a 5–item subset of the California Self–Evaluation Scale to measure self–esteem,[134,135] as well as the Personal Efficacy Scale,[132] the Somatization Scale of the Hopkins Symptoms Checklist,[136] and a substance use questionnaire.[33]

As moderating variables, we used a Social Desirability short form,[137] a dietary questionnaire,[138] an expectancy of benefits questionnaire,[86] and a compliance record. We took all psychological measures at baseline and again at 6 months.

Follow–Up and Data Collection

Blood Pressure Measurements

A trained research technician measured BP in the participant's right arm while the participant remained seated and resting for 5 minutes, recording measurements with a random-zero sphygmomanometer. We defined the diastolic BP as the fifth phase of the Korotkoff sounds with cuff size based on the participant's arm circumference. The technician took three successive readings at 30-second intervals and then averaged the sum. Participants were told not to practice any stress-reduction or relaxation techniques immediately before or during the BP recording. A clinician measured clinic BP on all visits during baseline, every month for 3 months after baseline, and then at 6 months.

Ambulatory Blood Pressure Monitoring

Ambulatory BP monitoring (ABPM) has been considered a stronger predictor of morbid outcomes from hypertension than either clinic or office measures. It correlates significantly more with LV mass than with office BP and is relatively free of placebo effects.[139] Furthermore, variability of 24-hour BP correlates with LVH and peripheral atherosclerosis.[61,117]

African American individuals may have distinctive 24-hour BP patterns (eg, lack of decline of BP at night that may predict LV morbidity more closely than daytime BP alone).[25] In this study, we assessed 24-hour BP patterns in all participants; we used Spacelabs 90207 ambulatory monitors (described elsewhere[140]) after the individual's clinic testing at baseline and at the end of the follow-up period. The ambulatory BP was then merged and subsequently analyzed.[141] We took ambulatory BP pressure measures at baseline and after 6 months.

Risk Factor Assessment

We assessed traditional cardiovascular risk factors with the TOMHS procedures at baseline and at 6 months.[90] We

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weighed participants (without shoes) on balance scales calibrated on a weekly basis and calculated body weight as the average of two baseline screening-visit weights. We then calculated body surface area from this average weight and height, and determined the level of physical activity from self-report diaries of type, frequency, and duration of activity. We converted this information into "physical activity points," each point comparable to 4 kilo-calories of energy expenditure.

To assess diet, we used 24-hour dietary recall at baseline and posttreatment and analyzed sodium intake, fat, and other nutrients. We used self-reports to evaluate tobacco, alcohol, and other substance use at baseline, and excluded from the study those participants who reported consuming more than 28 drinks per week. Our definition of one drink was 12 ounces of beer, 5 ounces of wine, or 1/2 ounce of liquor.

Cardiovascular-Related Measurements

We measured urinary sodium excretion because of its relationship to LVM in patients with mild hypertension[33] and estimated sodium intake from 24-hour urine collections at baseline and at the end of the treatment period. To determine total urinary sodium excretion for the overnight sample in mEq/L, we multiplied the sodium concentration by the volume of the urine, then standardized this to 8 hours for all participants. We also measured urinary creatinine to correct sodium excretion and assessed dietary sodium intake on the basis of food records the patients provided at baseline and after the treatment.

Statistical Analysis

To ensure an adequate sample size to detect the experimental effects of the magnitude we anticipated, we determined the number of participants in the study by power analysis.[142] We based the power and sample size estimates on changes in LVM and BP as the primary outcome measures. We anticipated a 13.1% reduction in LV mass in the TM group, based on the BP reductions obtained in our previous studies of TM and hypertension and the BP and LV mass reductions reported for the TOMHS trial. We expected that a sample size of 85 for each of the groups would provide 80% power to detect a reliable comparative reduction in LV mass of a clinically meaningful magnitude. We also based this sample size on a planned one-tailed comparison with an alpha criterion of .05 because of the clear direction of prediction.

We based all evaluations on both trial and intent-to-treat analyses.[143] All patients with missing data were to be assigned their last recorded value, except for those who dropped out because of rapidly escalating BP, who were assigned the maximum rate of increase observed among the participants in the sample. We also determined the correlation between outcomes and regularity of TM practice.

To determine the effect of TM on reducing LVM, relative to the health education control group, we used univariate analyses of covariance (ANCOVA) to examine outcomes for each separate LV mass measure. We used multiple regression to assess the potential modulating role of age and gender as treatment effects.

We also performed similar analyses to determine the relative effect of TM on ventricular diastolic function, on 24-hour BP monitoring, on psychological measures, and on cardiovascular risk factors. To determine the interrelationship of change in LV mass and function to change in clinic BP, ambulatory BP, psychosocial stress/quality-of-life factors, and risk factors, we performed multiple regression analyses with LVM and LV function at baseline as the dependent variable and the other variables as predictors. Then, to investigate plausible mechanisms responsible for treatment outcomes, we performed multiple regression analyses separately on intervention and control groups, with change in LVM and LV function as the dependent variable and change in the other key factors as predictors.

Conclusion

Hypertension and hypertensive heart disease are more severe and are associated with higher levels of cardiovascular morbidity and mortality in African Americans than in Whites. Psychosocial stress affects quality of life in African Americans and is strongly related to the development of hypertension and hypertensive heart disease. The TM technique has been reported to be effective in the reduction of physiological and psychological markers of stress and has demonstrated significant antihypertensive effect in African Americans. In this study, we compared a group using the TM technique with a control group receiving conventional education on cardiovascular risk factors.

We have presented the rationale and protocol for the use of the TM behavioral technique in reducing hypertension, LVH, and diastolic dysfunction in adult African Americans from an urban population. Studies on the effects of stress-reduction techniques on these pathological conditions for the Black community have not been previously described. Results of the clinical trial we have outlined will be presented in future articles. If significant, our findings would support the implementation of TM as an effective behavioral technique in the regular care of hypertension and hypertensive cardiovascular disease in African Americans, with potential important impact on national healthcare management.

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