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Impact of Transcendental Meditation on Ambulatory Blood Pressure in African-American Adolescents

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The objective of this study was to determine the impact of stress reduction on blood pressure (BP) in adolescents by the Transcendental Meditation (TM) program. African-American adolescents (aged 16.2 ± 1.3 years) with high normal systolic BP were randomly assigned to either 4-month TM ($n = 50$) or health education control ($n = 50$) groups. Ambulatory 24-h BP measures were recorded at pretest, 2- and 4-month post-tests, and 4-month follow-up. Greater decreases in daytime systolic BP ($P < .04$) and diastolic BP ($P < .06$) in the TM group compared with the control group across the visits demonstrate a beneficial impact of the TM program in youth at risk for the development of hypertension. Am J Hypertens 2004;17: 366–369 © 2004 American Journal of Hypertension, Ltd.

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Hypertension has its origins in childhood.[1] Because blood pressure (BP) tracks from late childhood into adulthood, youth with high-normal BP levels are at increased risk for hypertension.[1] The African-American population is at particular risk for hypertension, with disproportionately high rates compared with whites. In 1997, the National Institutes of Health announced an initiative for pediatric intervention studies of primary prevention of cardiovascular disease (CVD).[2] Previous findings with psychosocial and behavioral interventions have shown improved CVD outcomes in adults, and highlight the urgent need for such interventions to be introduced in youth, for CVD prevention, that may greatly benefit overall health and well-being, and also reduce healthcare costs over the long term.[2]

Given the inconsistencies that traditional lifestyle interventions (eg, physical activity, diet) have had on BP control and the potential role of psychosocial stress in the development of hypertension, stress reduction approaches may prove beneficial in the reduction of BP in youth.[1] To our knowledge, no stress reduction intervention studies involving adolescents have evaluated impact on ambulatory BP. On the basis of findings involving adults[3] and youth,[4] it was predicted that African-American youth who practiced Transcendental Meditation (TM) would exhibit greater decreases in ambulatory BP compared with a health education control group.

Methods

Study Population

The BP screenings were conducted on approximately 5000 African-American youth at five inner-city high schools in Augusta, GA. One hundred fifty-six subjects found to exhibit resting systolic BP in the ≥85th and ≤95th percentile for their age, sex, and height[5] on three consecutive occasions were invited to participate in the study. Subjects were pretested (discussed later) and randomly assigned by school to either 4-month TM or health education control (CTL) groups. The study was conducted during 4 years (eight school semesters) with two 4-month interventions per semester. Schools were comparable in total student body size and ethnic distribution. Order of interventions was randomly counterbalanced between schools with all schools receiving both the TM and CTL interventions by completion of the study. Students were assigned to only one intervention. Twelve subjects moved away or dropped out (7 TM, 5 CTL). Sixteen were excluded due to noncompliance (attendance <70%) with TM or health education classes, and 28 were excluded due to incomplete ambulatory BP data, that is, no pretest or only pretest (14

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TM, 14 CTL). The 50 TM (18 female subjects) and 50 CTL (19 female subjects) with complete data were used in the analyses.

Procedures

Height (with a stadiometer), weight (with a Detecto scale; Cardinal Scale Co., Webb City, MO), and waist and hip circumference measurements were recorded using established protocols[6] at pretest, 4-month post-test, and 4-month follow-up. Systolic BP, diastolic BP, and heart rate (HR) measures were recorded using the Spacelabs ambulatory BP monitor 90207 (Spacelabs, Inc., Redmond, WA). Measures were recorded from 6 AM to 11 PM every 20 min (daytime) and from 11 PM to 6 AM every 30 min (nighttime) in the natural environment during 24-h periods, at pretest, 2- and 4-month post-tests, and 4-month follow-up (ie, visits 1 to 4). On the basis of previous results, measurements of systolic BP <50 mm Hg and diastolic BP <30 mm Hg were deleted.[7,8] Similar to these studies,[7,8] data for transition periods (6 to 8 AM and 10 PM to midnight) were excluded from daytime and nighttime calculations. Data were reduced by averaging individual measures into daytime and nighttime levels. Means for systolic BP, diastolic BP, and HR required a minimum of 50% of the total possible observations (ie, minimum of 21 daytime; 6 nighttime) to be included in the analyses.

Interventions

The TM technique is a simple mental procedure practiced for 15 min twice a day while sitting comfortably with eyes closed and has been previously described.[3,4] After personal instruction, the TM group engaged in 15-min sessions at home and at school each school day and 15-min twice-daily individual home practice on weekends for 4 months. Daily TM sessions were fitted into the school schedule without taking time from the academic schedule. Typically, sessions were held during the homeroom period—in a separate and secluded quiet location—at the beginning of the school day.

The CTL group was presented a 4-month didactic series of 15-min lifestyle education sessions each school day based in part on National Institutes of Health guidelines on lowering BP through weight management, diet (increasing fruit and vegetable consumption and reducing caloric, fat, and sodium intake), and increasing physical activity. Sessions were intended to provide time and attention comparable to the TM subjects. The CTL group did not receive instructions in any specific stress reduction or relaxation techniques. Attendance was taken for all sessions at school. Subjects were paid $50 each for wearing the ambulatory monitor.

Statistical Analyses

Daytime and nighttime systolic BP, diastolic BP, and HR were analyzed using mixed model repeated-measures ANOVAs, that is, 2 (group: TM versus CTL) by 4 (time: pretest, 2-, 4-, and 8-month post-tests) by 2 (sex: male versus female subjects) to determine group differences across the visits. The Hollingshead Four Factor Social Status Index was used as an index of socioeconomic status.[9]

Table 1. Descriptive characteristics at pretest

	TM (n = 50; 19F, 31M)	CTL (n = 50; 18F, 32M)
Age (y)	16.0 ± 1.3	16.3 ± 1.4
Weight (kg)	82.4 ± 26.8	83.6 ± 24.7
Height (cm)	170.4 ± 9.6	170.2 ± 10.0
Body surface area (m^2)	1.9 ± 0.3	1.9 ± 0.3
Body mass index (kg/m^2)	28.0 ± 7.4	28.7 ± 7.7
Waist circumference (cm)	89.0 ± 19.1	89.7 ± 18.8
Hollingshead Four Factor Social Status Index	35.7 ± 13.0	34.8 ± 12.7
Single mother head of household	63%	60%

Values are mean ± SD. All P values >.21.
CTL = control group; TM = Transcendental Meditation.

Results

Anthropometric Measures and Compliance

Average attendance of the TM and CTL groups at the school sessions during the 4-month intervention was 62.9% and 76.8%, respectively. Average self-reported compliance with TM practice at home was 75.9%. As listed in Table 1, there were no significant differences between groups for any baseline anthropometric parameter (all $P > .21$).

Ambulatory Hemodynamic Measures

Systolic BP A main effect for time indicated a decrease in daytime systolic BP across the four visits ($P < .006$). A group by time interaction revealed that the TM group exhibited a greater decrease across visits in daytime systolic BP compared with the CTL group ($P < .04$; Table 2 and Fig. 1A). There were also gender effects with male subjects showing higher daytime systolic BP (means across visits: 131.3 ± 0.8 *v* 125.5 ± 1.1 mm Hg; $P < .0001$), and nighttime systolic BP (means across visits: 119.2 ± 1.0 *v* 113.3 ± 1.3 mm Hg; $P < .0005$). There were no other statistically significant main or interaction effects (all $P > .41$).

Diastolic BP A main effect for time indicated a decrease in daytime diastolic BP across the four visits ($P < .03$). A trend for group by time interaction revealed that the TM group exhibited a greater decrease than the CTL group across the four visits ($P < .06$; Table 2 and Fig. 1B). There

Table 2. Hemodynamics by group and time

	Visit 1 (pretest)	Visit 2 (2 mo post-test)	Visit 3 (4 mo post-test)	Visit 4 (4 mo follow-up)
		Daytime measures		
TM group				
SBP	129.2 ± 1.1	126.4 ± 1.3	124.9 ± 1.1	125.3 ± 1.2
DBP	75.3 ± 0.9	72.1 ± 1.2	71.2 ± 1.1	72.9 ± 1.2
HR	85.5 ± 1.4	82.7 ± 1.8	81.4 ± 1.5	81.7 ± 1.5
Control group				
SBP	130.6 ± 1.1	131.2 ± 1.3	129.8 ± 1.1	129.7 ± 1.2
DBP	75.8 ± 0.9	76.6 ± 1.2	75.1 ± 1.1	75.7 ± 1.2
HR	83.7 ± 1.4	84.8 ± 1.8	81.6 ± 1.5	83.1 ± 1.5
		Nighttime measures		
TM group				
SBP	116.2 ± 1.4	114.3 ± 1.6	115.0 ± 1.7	113.5 ± 1.4
DBP	60.5 ± 1.0	60.7 ± 1.3	61.4 ± 1.3	60.7 ± 1.1
HR	72.6 ± 1.4	71.8 ± 2.0	71.0 ± 1.4	68.9 ± 1.3
Control group				
SBP	117.4 ± 1.3	118.1 ± 1.5	117.4 ± 1.6	117.9 ± 1.4
DBP	62.3 ± 0.9	63.6 ± 1.2	62.8 ± 1.2	62.9 ± 1.1
HR	69.9 ± 1.3	71.3 ± 1.8	70.8 ± 1.4	68.4 ± 1.3

Values are least-square means ± estimated SE.
SBP = systolic blood pressure (mm Hg); DBP = diastolic blood pressure (mm Hg); HR = heart rate (beats/min); other abbreviations as in Table 1.

were no other significant main or interaction effects for diastolic BP (all $P > .12$).

Heart Rate A main effect for time indicated a decrease in daytime HR across the four visits ($P < .003$). There were sex differences, with male subjects exhibiting lower daytime (means across visits: 79.7 ± 1.1 *v* 86.4 ± 1.4 beats/min; $P < .0001$) and nighttime (means across visits: 67.0 ± 1.0 *v* 74.2 ± 1.3 beats/min; $P < .0001$) HRs. There were no other main or interaction effects for HR (all $P > .06$).

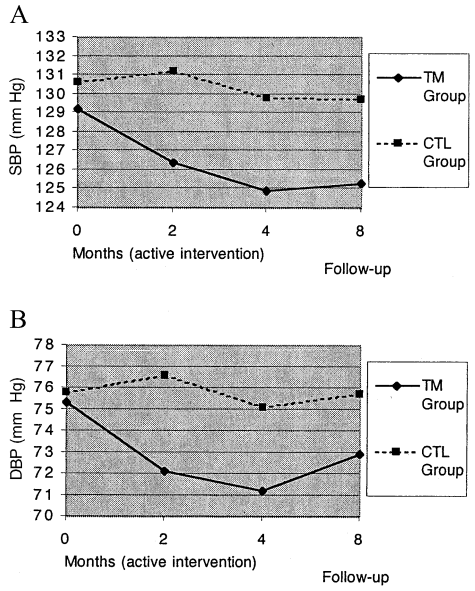

FIG. 1. Comparison of daytime ambulatory blood pressure (BP) means between Transcendental Meditation (TM) and control (CTL) groups at pretest, 2- and 4-month active intervention, and 8-month follow-up for (**A**) systolic BP (SBP) ($P < .04$) and (**B**) diastolic BP (DBP) ($P < .06$).

Discussion

This study examined the impact of a 4-month participation in the TM technique on ambulatory BP in African-American adolescents with high normal BP. The TM group exhibited greater decreases in ambulatory daytime systolic BP compared with little or no change in the CTL group across the 8-month study. Importantly these changes were maintained at the 4-month follow-up after formal cessation of the intervention. Although a trend, a similar pattern was observed for daytime diastolic BP. These findings are consistent with and extend adult studies reporting that TM reduced clinic BP levels significantly in older hypertensive African Americans at 3 months,[3] normotensive Asian medical students at 1.5 and 3 months,[10] and in normotensive white college students during 4 months.[11]

Few BP-related stress reduction studies have been conducted in youth, and findings have been mixed. Relaxation training combined with increased physical activity for 4 months failed to yield any BP differences in community-home boys compared with a control group.[12] A daily progressive muscle relaxation (PMR) program conducted for 3 months at school in teenagers with high-normal BP showed a 5.3 mm Hg greater decrease in their systolic BP compared with a waiting list control condition.[13] A 4-month follow-up revealed that the systolic BP of the PMR group had returned to pretreatment levels. The

present findings at completion of the 4-month intervention compare favorably with that study[13] in that the TM group exhibited a 3.5 mm Hg greater decrease in systolic BP and a 3.4 mm Hg greater decrease in diastolic BP compared with the CTL group. The present findings extend those findings[13] in that the decreases were maintained at follow-up 4 months later. In the present study, as well as other studies, neither lifestyle modification education, nor waiting list control groups showed significant decreases in resting BP.[3,12,13]

The present findings were not attributable to differences in anthropometric measurements (eg, height, weight, and adiposity), demographics (ie, socioeconomic status), or expectations of health benefits because the TM and control groups were similar on these parameters at pre- and post-intervention. The findings were not impacted by changes in physical activity or exposure to environmental stress. Furthermore, the subjects resided in the same geographic locale (ie, lower socioeconomic status neighborhoods). There were no significant differences between the groups in changes in weight or adiposity, which would provide indication of significant diet or physical activity lifestyle changes. Although the intervention did not significantly impact body mass index, the TM technique lowered BP irrespective of the fact that approximately 70% of the cohort were above the 85th percentile for age and sex.[14]

Underlying physiologic pathways responsible for the beneficial impact of TM on BP are unclear. The TM practice has been associated with decreases in sympathetic nervous system tone, hypothalamic-pituitary-adrenocortical axis activation, and cortisol levels, which have been associated with reduction in BP.[15] The TM practice has also been shown to reduce BP reactivity to acute behavioral stress in the laboratory setting.[4] Over time, a reduction in the cascade of neurohormonal activity may result in decreased shear stress on the circulatory system and reduced load on the heart. These events may result in improved myocardial and vascular function, leading to decreased BP levels, thereby helping to prevent early onset of hypertension.

Whether TM practice resulted in reduced neurohormonal and hemodynamic arousal to acute stressor episodes in the field is unknown. Future studies would benefit from inclusion of actigraphs, repeated salivary sampling of cortisol levels, 24-h urine output for catecholamine levels, and momentary event sampling with user-friendly personal electronic digital assistant methodology to evaluate posture, activity levels, and emotional responses to naturally occurring behavioral stressors. Such information would shed light on the potential beneficial impact of TM on hormone levels and hemodynamic responsivity to acute behavioral stressors, as well as permit controlling for potential confounding influences of postural changes and physical activity. Because it is frequently many years before youth display overt clinical symptoms of CVD, longitudinal studies are needed to examine the impact of meditation on the development of preclinical manifestations of increased hypertension risk.

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