IMPACT OF BREATHING AWARENESS MEDITATION ON AMBULATORY BLOOD PRESSURE AND SODIUM HANDLING IN PREHYPERTENSIVE AFRICAN AMERICAN ADOLESCENTS

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Objectives: This study evaluated the impact of a breathing awareness meditation (BAM) program on ambulatory blood pressure and sodium handling in African American adolescents with high-normal systolic blood pressure (SBP) levels.

Design and Methods: Following three consecutive days of SBP screenings, 66 eligible ninth graders were randomly assigned by school to either BAM ($n=20$) or health education control ($n=46$) groups. The BAM group engaged in 10-minute BAM sessions at school and at home each day for three months. Teachers conducted sessions at school during health classes. Before and after the intervention, overnight urine samples were collected, and ambulatory SBP, diastolic blood pressure, and heart rate were recorded periodically for 24 hours.

Results: Significant changes before and after the intervention were observed between BAM and control groups for SBP during school hours (−4.7 vs .9 mm Hg, $P<.05$), SBP at night (−4.8 vs −.6 mm Hg, $P<.01$), and heart rate during school hours (−6.7 vs −2.3 bpm, $P<.02$), adjusted for their respective pre-intervention levels. The overnight urinary sodium excretion rate decreased in the BAM group but increased in the control group (−.3±4.9 vs 1.1±4.0 mEq/hour, $P<.03$).

Conclusions: These findings demonstrate the potential beneficial impact of BAM taught by school health teachers on blood pressure control in the natural environment in African American youth at risk for development of hypertension. (*Ethn Dis*. 2008;18:1–5)

Key Words: Adolescents, Blood Pressure Monitoring, Meditation, Hypertension, Sodium Handling, African American, Clinical Trials

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INTRODUCTION

Essential hypertension remains a major health problem in the United States,[1] and the prevalence of hypertension among children is increasing.[2] African Americans experience a higher prevalence and earlier onset of hypertension than other ethnic groups in the United States.[3] This disparity begins early; African Americans have higher blood pressures than do other ethnic groups from childhood onward.[4] A number of stress-related factors contribute to hypertension, particularly among African Americans. Beginning in childhood, African Americans are exposed to social and environmental stressors (eg, aversive social interactions related to socioeconomic status inequality, racism, high crime rates)[5,6] and exhibit exaggerated blood pressure reactivity to behavioral stress.[7] Since blood pressure ranking tracks from late childhood onward,[8] African American adolescents with high-normal blood pressure are at increased risk for hypertension from childhood onward.[9]

Behavioral stress induces increased sodium retention. Normal sodium handling refers to the body's ability to restore sodium balance following cessation of stress. Impaired sodium handling has been implicated in the greater prevalence of hypertension in African Americans.[10–12] For example, acute laboratory behavioral stress studies have demonstrated that a substantial percentage of African Americans retain sodium (impaired sodium handling) rather than exhibit the expected post-stress response of increased sodium excretion in response to stress-induced blood pressure increases.[13–15] Sympathetic nervous system activation that occurs during stress to promote sodium retention plays a major role in this process.[13,16–20] In addition, stress reduction may decrease sodium appetite, as indicated by decreased 24-hour urinary sodium excretion.[21]

Sympathetic hyperactivity has been implicated in the development of hypertension and cardiovascular disease complications.[22] Stress-reduction practices, such as meditation, may decrease neurohormonal activity and help control the hypothalamic-pituitary-adreno-cortical axis and the renin-angiotensin-aldosterone system.[21] Meditation can affect neuroendocrine status, metabolic function, and related inflammatory responses.[23] Meditation may stimulate the vagus nerve, thus enhancing parasympathetic output and shifting the autonomic nervous system balance from mainly sympathetic to parasympathetic. This shift causes favorable changes in cardiac-vagal function.[24] Programs such as Transcendental Meditation™ have shown decreased resting[25] and ambulatory blood pressure,[26] decreased cardiovascular reactivity to laboratory stress,[25] and decreased sodium excretion levels, suggesting decreased stress-activated salt appetite.[21]

There is a need for development and evaluation of an effective, easily disseminated primary prevention program for the school setting which can beneficially impact blood pressure and sodium

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handling. Breathing awareness meditation (BAM) is one such program that is a component of the mindfulness-based stress reduction program;[27] it does not have a formal cost structure and does not require a certified instructor. Only one study has examined the effect of BAM on blood pressure control in adolescents: BAM reduced daytime blood pressure and heart rate in a multiethnic sample of normotensive middle schoolers.[28] To date, the effect of BAM on sodium handling has not been assessed.

The current study is an initial effort to investigate the effectiveness of BAM on ambulatory blood pressure and sodium handling, as defined by overnight urinary sodium excretion rate (mEq/hour), in prehypertensive African American adolescents. The classroom teacher conducted the intervention as part of regular health classes in school. Based on previous findings,[25,26,28] we predicted that adolescents with high-normal systolic blood pressure (SBP) who practiced behavioral stress reduction via BAM would exhibit greater decreases in ambulatory blood pressure and overnight urinary sodium excretion.

METHODS

Subjects

A total of 510 African American adolescents at two high schools participated in three consecutive days of screenings at school to determine eligibility for participation. Height (via stadiometer) and weight (via Detecto scale, Cardinal Scale Manufacturing Co., Webb City, MO) measurements were recorded using established protocols.[25] Resting seated SBP was recorded from the right arm for 10 minutes (four readings at 0, 5, 7, and 9 minutes) with Dinamap 1846SX monitors (Critikon, Inc. Tampa, FL). The first measurement of each day was discarded, and the other three measurements were averaged. Students were excluded from entering or continuing the study for any of the following reasons: 1) parental report of history of congenital heart defect, diabetes, sickle cell anemia, asthma, or any chronic illness or health problem that requires regular pharmacologic treatment; 2) involvement in or plan to engage in a formal exercise or health promotion program, including organized individual or team sports; 3) unwillingness to accept randomization into treatment groups; 4) parental report of not "African American" or "Black"; 5) self-reported pregnancy at any point in the study; 6) SBP lower than 75th or higher than 95th percentile for age, sex, and height on any school screening measurement.

We found 114 students whose SBP was $\geq$ 75th and $\leq$ 95th percentile for age, sex, and height on three occasions.[28] Ninety-six students consented to participate, and 66 were randomly assigned by school to either BAM or the health education control group (Table 1). Thirty students who were eligible and consented to participate could not be assigned to a treatment group because of academic scheduling conflicts. Within a single calendar year, two control groups participated at different times. One (n=25) occurred in a different school with a demographically similar student body during the same time as the BAM group. The other (n=21) was conducted the next semester in the same school as the previously conducted BAM intervention. This study is part of a larger ongoing study examining effects of various stress reduction programs on cardiovascular function at rest, during laboratory stress, and in the natural environment. The Human Assurance Committee of the Medical College of Georgia approved the study.

Table 1. Baseline characteristics of 66 prehypertensive African American students assigned to breathing awareness meditation (BAM) or control groups

Characteristic	BAM (n=20)	Control (n=46)
Age (years)	15.0±.7	15.3±.9
Sex (male/female)	9/11	19/27
Weight (kg)	70.9±26.1	72.4±23.1
Height (cm)	164.9±7.0	165.1±7.8
Body mass index (kg/m^2)	25.9±8.7	26.4±7.7
Waist/hip ratio	.8±.6	.8±.7

Values are mean ± standard deviation. All Ps>.24.

Intervention

BAM involves focusing upon the moment, sustaining one's attention to the breathing process, and passively observing thoughts. This technique is taught as Exercise 1 of Mindfulness-based Stress Reduction Program.[27] The individual sits upright in a comfortable position with eyes closed. Participants are instructed to focus on diaphragm movements while breathing in a slow, deep, relaxed manner. If attention shifts toward unwanted thoughts, ideas or images, the individual is taught to acknowledge and accept them without making judgments about them and shift attention back to diaphragmatic breathing. The BAM group engaged in 10-minute sessions at school and at home after school each day for three months. Self-reported compliance with BAM for home practice was 86.6%±7.4%. The control groups were given a weekly 20-minute session on preventing high blood

Table 2. Ambulatory systolic and diastolic blood pressure and heart rate

	BAM (*n*=17)		Control (*n*=39)	
	Pre	Post	Pre	Post
SBP				
Daytime (school)*	124.7±8.6	120.5±9.1	127.6±7.3	126.4±8.4
Daytime (after school)	123.9±7.0	122.6±7.1	126.1±8.6	124.4±8.1
Nighttime†	111.4±5.8	107.1±5.4	113.1±7.9	112.2±6.6
DBP				
Daytime (school)	73.3±8.1	71.0±7.9	76.0±5.7	75.4±6.7
Daytime (after school)	74.4±7.0	72.5±6.7	74.0±6.7	71.4±7.1
Nighttime	59.8±7.2	57.1±4.7	61.9±6.2	60.6±6.3
Heart Rate				
Daytime (school)*	89.7±15.3	83.2±9.1	90.2±12.3	87.8±8.9
Daytime (after school)	88.2±9.1	87.6±7.9	88.9±9.1	85.5±10.4
Nighttime	75.4±11.5	72.8±10.7	74.3±9.2	71.8±8.2

* $P<.05$.
† $P<.01$ for group effect on pre-intervention adjusted change scores.
Values are unadjusted means ± standard deviations.

pressure using guidelines for adolescents.[29] This instruction included information on lowering blood pressure through weight loss, diet (reducing fat and sodium intake), and physical activity. Classroom teachers conducted all teaching sessions during health classes at school.

Measurements

Before and after the intervention, ambulatory SBP, diastolic blood pressure (DBP), and heart rate were recorded for 24 hours; measurements were taken every 20 minutes during self-reported after school waking hours and every 30 minutes during self-reported school and sleep hours using Spacelabs 90207 monitors (SpaceLabs, Inc., Redmond, WA). These instruments have been validated,[30] and acceptability of readings was based on established criteria.[31–33] Hourly averages were obtained by averaging all readings for each clock hour and then reduced by averaging hourly averages into daytime at school (7 am to 3 pm), after school (3 pm to 11 pm), and nighttime (11 pm to 7 am) measures. Primary outcome measures were changes in ambulatory daytime (at school and after school) and nighttime SBP, DBP, and heart rate from baseline to three months after the intervention. Not all subjects completed all aspects of the ambulatory testing as reflected in Table 2. Overnight urine samples were collected and analyzed for overnight urinary sodium excretion rate (mEq/hour). Subjects were provided urine collection containers along with written and verbal instructions for collection and were instructed to note urine void times at bedtime and waking.

Statistics

Changes in daytime (school and after school) and nighttime SBP, DBP, and heart rate measures for each group were compared by using a series of analyses that covaried the respective pre-intervention values (ANCOVAs). Before and after the intervention, overnight urine samples were collected and analyzed for urine volume, sodium content, and sodium excretion rate. Changes in these variables were compared by using a series of ANCOVAs that covaried pre-intervention and school attendance values.

RESULTS

Pre-intervention anthropometric data are shown in Table 1. Values for the pre- and 3-month post-intervention hemodynamic measures are shown in Table 2.

Ambulatory Systolic Blood Pressure

Significant differences in pre- to post-intervention mean change scores (± standard error) were observed between BAM and control groups for SBP during school (−4.7±1.6 mm Hg vs −.9±1.0 mm Hg, $P<.05$) and nighttime SBP (−4.8±1.3 vs −.6±.8 mm Hg, $P<.01$), adjusting for the respective pre-intervention SBP values. Mean values for SBP during school and nighttime SBP decreased more in the BAM group than in the control group. Changes in adjusted SBP during after-school hours were similar for each group (−1.8±1.4 mm Hg vs −1.5±.9 mm Hg, $P=.85$).

Ambulatory DBP

Adjusting for pre-intervention values, no statistically significant mean change score differences were observed between BAM and control groups for DBP during school (−2.9±1.3 mm Hg vs −.4±.9 mm Hg, $P=.12$), nighttime DBP (−3.4±1.2 mm Hg vs −1.0±.8 mm Hg, $P=.10$), or after school DBP (.3±1.2 mm Hg vs −2.5±.8 mm Hg, $P=.13$).

Ambulatory Heart Rate

Significant mean differences were observed between BAM and control groups for heart rate during school (−6.7±1.5 bpm vs −2.3±1.0 bpm, $P=.017$), adjusting for pre-intervention values. No statistically significant pre-intervention adjusted mean differences were observed between BAM and control groups for nighttime heart rate (−2.2±1.9 bpm vs −2.2±1.2 bpm, $P=.85$) and after school heart rate (.9±2.0 bpm vs −3.3±1.3 bpm, $P=.30$).

Sodium Handling

Overnight urinary excretion measures are shown in Table 3. After excluding subjects with <70% attendance and adjusting for baseline values and attendance (BAM, $n=11$; CTL, $n=28$), overnight urinary sodium excretion rate decreased from pre- to post-intervention in the BAM group but

Table 3. Overnight urinary volume and sodium levels, and sodium retention rate

	BAM (*n*=11)		Control (*n*=28)	
	Pre	Post	Pre	Post
UV†	314±137	260±135	328±188	320±147
UNa^+†	1.8±1.7	1.6±1.6	2.1±2.3	2.5±2.4
UNaV*†	5.1±2.9	4.7±3.3	5.6±3.7	6.6±3.8

Values are unadjusted means ± standard deviations.
* $P<.05$ for group effect on adjusted change scores.
† $P<.03$ for group by time effect on change scores adjusted for pre-intervention values and attendance.
UV=urinary volume (mL); UNa^+ =urinary sodium (g); UNaV= urinary sodium excretion rate (mEq/hr).

increased in the control group (−1.6±1.1 vs 1.5±.7 mEq/hr, $P<.03$), as did overnight urine sodium content (−1.1±.7 vs .8±.4 g, $P<.03$) and overnight urine volume (−108±44 vs 12±26 mL, $P<.03$).

DISCUSSION

Our findings show that a three-month BAM intervention decreased SBP and heart rate during school, SBP during nighttime, and urine sodium excretion overnight in a group of African American adolescents with high-normal blood pressure. These findings are consistent with the results of Walton et al,[21] who reported that young adults who practiced Transcendental Meditation™ significantly lowered their 24-hour sodium excretion rate. These findings may indicate a decrease in sodium intake consistent with a decrease in chronic stress.[34]

Our study demonstrates the potential beneficial effect of BAM (breathing awareness meditation) on cardiovascular functioning and sodium handling in African American adolescents at risk for developing hypertension.

Our study demonstrates the potential beneficial effect of BAM on cardiovascular functioning and sodium handling in African American adolescents at risk for developing hypertension. The underlying physiologic mechanism responsible for the relationship between stress and sodium intake is not fully understood but is thought to be partly mediated by increased sympathetic nervous system activity, which results in higher levels of stress-related hormones such as aldosterone that directly affect sodium appetite.[21,35,36] Stress reduction through meditation is, therefore, expected to decrease sodium intake. This study did not deal with the effect of BAM on sodium handling in response to acute stress. In such a case, BAM might be expected to increase sodium excretion in the aftermath of a stressful event. Future studies should address this issue.

The ambulatory blood pressure findings compare favorably with a three-month BAM intervention that involved a sample of normotensive middle school students in which decreases of 2.0 mm Hg in daytime SBP and 5.3 bpm in daytime heart rate were observed, compared to slight increases in controls.[28] In another study of prehypertensive adolescents, a TM group experienced a 4 mm Hg decrease in ambulatory SBP after eight months compared to controls.[26]

Although promising, the present study findings are preliminary and should be interpreted cautiously for several reasons. Although the two schools involved were well matched demographically (eg, comparable size of student body, percentage of African American youth and free lunch recipients), differences among the teachers may have influenced the findings. Furthermore, a time confound may exist between the control groups that participated in the study at different times. However, no significant differences were observed between the two control groups on any of the change score variables for either the hemodynamic or urinary sodium measures, and an evaluation of quality of teacher implementation revealed no substantial differences in quality of presentation. Our preliminary analyses with regard to sodium handling suggested that a certain level of participation was necessary to have a treatment effect. Thus, for these variables we excluded students who attended <70% of the sessions. Furthermore, within this narrowed range, attendance was still a significant covariate. Perhaps with larger sample sizes, a more precise cutoff point for participation could be determined. Additionally, it might be useful in future studies to collect several consecutive overnight urine samples to ensure more accurate representative sampling of these measures.

These findings have implications for public health and preventive medicine. The central implication of our findings is that if further school-based research finds BAM to be useful in sustaining blood pressure control over the long term, school-based, nonpharmacologic primary prevention has potential to decrease cardiovascular morbidity and mortality. The intervention can be taught by school personnel with minimal training. Simple behavioral interventions, which can be taught by members of the community rather than by specially trained instructors, may quickly disseminate in minority communities. If results are replicated in a larger sample and sustained over time, these programs could be disseminated into the regular school curriculum. This possibility is especially promising in an era of diminishing healthcare resources at state and federal levels and points to

the sustainability of an intervention that would require little funding.

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