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Breathing Awareness Meditation and LifeSkills® Training Programs Influence Upon Ambulatory Blood Pressure and Sodium Excretion Among African American Adolescents

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Abstract

Purpose—Evaluate impact of breathing awareness meditation (BAM), Botvin LifeSkills® Training (LST), and health education control (HEC) on ambulatory blood pressure (BP) and sodium excretion in African American (AA) adolescents.

Methods—Following three consecutive days of systolic blood pressure (SBP) screenings, 166 eligible participants (i.e., SBP > 50^{th} – 95^{th} percentile) were randomized by school to either BAM (n = 53), LST (n= 69), or HEC (n=44). In-school intervention sessions were administered for three months by health education teachers. Before and after the intervention overnight urine samples and 24-hour ambulatory SBP, diastolic blood pressure (DBP), and heart rate (HR) were obtained.

Results—Significant group differences were found for changes in overnight SBP and SBP, DBP and HR over the 24-hour period and during school hours. The BAM treatment exhibited the greatest overall decreases on these measures (Bonferroni adjusted, *p*s <.05). For example, for school-time SBP, BAM showed a change of −3.7 mmHg compared to no change for LST and a change of −0.1 mmHg for HEC. There was a non-significant trend for overnight urinary sodium excretion (*p* = .07) with the BAM group displaying a reduction of −.92 ± 1.1 mEq/hr compared to increases of .89 ± 1.2 mEq/hr for LST, and .58±0.9 mEq/hr for HEC group.

Conclusion—BAM appears to improve hemodynamic function and may impact sodium handling among AA adolescents at increased risk for development of cardiovascular disease (CVD).

Keywords

adolescents; ambulatory blood pressure; breathing awareness meditation; Botvin LifeSkills® Training; clinical trial; sodium excretion

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INTRODUCTION

Globally, essential hypertension (EH) is the major cause of heart disease and stroke and the number one attributable risk factor for mortality [1]. African Americans (AAs) experience higher prevalence and earlier onset of EH compared to other ethnic groups [2,3]. Incidence of pediatric EH has escalated [4] with much higher increases reported among minority adolescents, especially AAs [5]. Epidemiologic studies have shown that BP levels are monotonically associated with future development of cardiovascular morbidity and mortality [6]. Prospective longitudinal studies have shown that BP percentile ranking tracks from late childhood into adulthood [7]. Thus, AA adolescents with BP between the 50^{th} and 95^{th} percentiles for age and sex (i.e. normotensive to pre-hypertensive) have an increased risk of developing CVD [8,9].

Exposure to chronic psychosocial stress has been identified as playing a contributory role in development of EH [10]. Persistent hyperactivation of the sympathetic nervous system (SNS) and the hypothalamic pituitary adrenocortical axis have been implicated as underlying mechanisms linking stress exposure to development of EH [11,12]. One effect of stress-induced SNS activation is increased sodium appetite [13,14]. Increased intake of salt-laden foods leads to an increased excretion of sodium as BP increases to restore sodium homeostasis via natriuresis [15]. AA's exhibit a higher prevalence of salt sensitivity than Caucasians [16] and those who are salt sensitive require an even higher systemic pressure to affect the level of natriuresis required to maintain steady-state sodium homeostasis [17]. Decreases in stress may reduce sodium consumption which will be reflected by decreased overnight sodium excretion, as well as decreased BP levels required for natriuresis, especially among salt sensitive individuals. Evidence indicating chronic stress contributes to EH development has resulted in a plethora of behavioral stress reduction programs among pre-hypertensive and or hypertensive adults [18-20]. A recent meta-analysis examining 17 stress reduction program trials among adults with elevated BP indicated that cognitive behavioral stress management and Transcendental Meditation® (TM) had the largest BP reductions [20]. With regard to stress-induced sodium appetite, Walton et al. [12] found that TM reduced 24-hour sodium excretion suggesting that, as seen in animal studies stress, stress reduction results in reduced sodium appetite [13].

Few pediatric stress reduction interventions have been conducted directed at improving BP control. One study involving AA adolescents reported an average 4.8 mmHg decrease in resting SBP for TM compared to an average increase of 2.6 mmHg for a control group [21]. A second study with AA adolescents reported an average 4.3 mmHg decrease for daytime ambulatory SBP for TM compared to a .8 decrease for a control group [22]. In another study, BAM was compared to health education controls in AA adolescents with high normal SBP. After three months, BAM resulted in greater decreases in 24-hour ambulatory SBP and decreased overnight sodium excretion compared to the control group [23] which is consistent with Walton et al.'s [12] findings that meditation reduced 24-hour sodium excretion.

Although cognitive behavioral BP control programs have been successful among adults [20], to date this type of intervention has not been conducted for BP control in adolescents. The Botvin LifeSkills® Training program (LST) has been methodically tested in schools [24]. It has been found to facilitate development of management skills for reducing stress, increasing coping skills and improving self-esteem [24]. The current study is an initial effort to investigate the effectiveness of BAM, LST, and HEC on ambulatory BP and sodium handing among AA adolescents at increased risk for CVD development.

METHODS

Subjects

A total of 1698 students participating in semester-long ninth grade health education classes were screened over a four-year period to determine eligibility for participation. Eligibility criteria included having: (1) resting SBP between 50th to 95th percentile for age, height and sex on three consecutive occasions at school [8]; (2) parental report of no history of congenital heart defect, diabetes, sickle cell anemia, asthma, or any chronic illness or health problem that requires regular pharmacological treatment; (3) no current or planned engagement in a formal exercise or health promotion program (including organized individual or team sports); (4) willingness to accept randomization into treatment groups; (5) parental report of being “African American” or “Black”, and (6) never pregnant at any point in the study.

One hundred seventy-five met eligibility criteria. Written informed consent was obtained and individuals were randomly assigned by school to treatment group. Nine participants were identified as having extreme 24-hour ambulatory values (i.e., ≥ 3 SD's for entire cohort) and deleted from statistical analyses. Final distribution of subjects by treatment group was as follows: BAM; n = 53, (21 males), LST; n = 69, (30 males), and HEC; n = 44 (17 males).

Procedures

BP Screening—The Human Assurance Committee of the Medical College of Georgia approved the study. Three consecutive days of school based casual BP screenings were conducted to determine eligibility. Height was measured by stadiometer and weight by a Detecto CN20 scale (Cardinal Scale Manufacturing Co., Webb City, MO). Seated SBP was recorded using Dinamap 1846SX monitors (Critikon, Inc. Tampa, FL) at minutes 5, 7, and 9 of a 10 minute rest period. The first measurement each day was discarded and the other two measurements were averaged.

Interventions—The three-month interventions were conducted across two high schools by six health education teachers during their regular health education class periods. Students taking these classes do not take physical education during that term.

All students within the classroom received the intervention but only those randomized to the study completed testing measures. Within each school, one teacher per semester was randomly assigned to teach an intervention and was provided supervised training by program instructors. Quality of intervention sessions and treatment fidelity were assessed weekly by a single rater using three-item Likert scale ratings (0-4 scale) on thoroughness, class attentiveness, and enthusiasm. All Instructors were rated as competent in implementing the various components throughout the three-month intervention (i.e., average of ratings: 3.34±0.26 for thoroughness; 3.28±0.32 for class attentiveness; 3.31±0.27 for enthusiasm). No significant differences between treatment groups, schools, and teachers or interactions of these factors were observed for any of the components (all *p*s> .05). Statistical differences were observed for attendance between the two schools (77% vs 90%, p = .01). These differences were primarily due to several of the cohorts in one of the schools experiencing repeated class cessations due to bomb threats and fire alarm activations. Attendance was not statistically different by treatment group (p = .52) and the group by school interaction was not significant (p =.46).

Breathing Awareness Meditation (BAM)—BAM is exercise one of the Mindfulness-Based Stress Reduction Program [25]. Practice involves focusing upon the moment, sustaining attention on the breathing process and passively observing thoughts. The individual sits upright with eyes closed and focuses on diaphragm movements while breathing in a slow, deep, relaxed manner. Ten-minute sessions were conducted during health education class and at home each week day. On weekends, subjects practiced 10 minute sessions twice daily. Self-reported compliance for home practice was 86.6±7.4 %. Average in-school attendance was 79% of total sessions.

LifeSkills Training (LST)—Weekly 50-minute sessions using selected components of the LST program involved group discussions, passive and active modeling, behavioral rehearsal, feedback, reinforcement and behavioral homework assignments. The components provided training in problem-solving skills, reflective listening, conflict resolution, and anger management to enhance social skills, assertiveness, and personal and social competence [24]. No relaxation or stress reduction techniques were given to the LST or HEC groups. Average in-school attendance was 86%.

Health Education Control (HEC)—Weekly health education lessons consisted of 50-minute sessions on CV health-related lifestyle behaviors based upon NIH guidelines for youth and included brochures, handouts, videotapes, discussions and recommendations for increasing physical activity (e.g., walking, sports, etc.), and maintaining prudent diets (e.g., reducing fat intake). HEC is considered a “usual practice” control group. Sessions were intended to provide comparable amounts of time and attention received by the BAM and LST groups. In-school average attendance was 85%.

Ambulatory Hemodynamic Monitoring—Before and following the intervention, ambulatory SBP, DBP, and HR were recorded for 24 hours; measurements were recorded every 30 minutes during school, every 20 minutes during after school waking hours, and every 30 minutes during sleep hours using Spacelabs 90207 monitors (SpaceLabs, Inc., Issaquah, WA). Ambulatory BP is a better predictor of EH than casual BP [26]. The instrument has been validated [27] and acceptability of ambulatory readings was based on established criteria [28]. Hourly averages were obtained by averaging all readings for each clock hour across the following time periods: daytime at school (7 a.m. to 3 p.m.), afterschool (3 p.m. to 10 p.m.), nighttime (12 a.m. to 7 a.m.), and 24-hour periods. No more than two weeks passed between intervention cessation and post-test evaluations. Participants were encouraged to continue practice of intervention skills after formal classroom training ended.

Overnight Urinary Sodium Excretion—Overnight urine samples were collected for examination of urinary sodium excretion rate (UNaV; mEq/hour) at the same time ambulatory readings were recorded. Subject's urine was collected at bedtime and upon morning awakening using take-home containers. Samples were checked for adequate urine volume (i.e., > 80 ml), and overnight creatinine excretion (i.e., ≥ 1.17 mg/kg; 5^{th} percentile cutoff among 14-18 year olds) [29]. No dietary manipulation was made across groups and sodium intake was not recorded. UNaV for all subjects should represent the usual intake from their everyday diet [30].

Descriptive Measures—In addition to the previously described anthropometric and BP measurements collected at pre-intervention, information was collected on age, sex, family history of essential hypertension, and socio-economic status (SES) using the Hollingshead social status index [31]. Expectation of health benefits was assessed with three questions for each intervention which determined expectations that HEC, BAM, and LST would lower BP, improve physical health, and improve mental health/well-being. A five-item Likert scale was used (not at all, a little, somewhat, a lot, very much). The three questions were summed. Cronbach's **a** was .72 for HEC, .82 for BAM, and .84 for LST.

Perceived Stress Scale—Participants completed the 4-item perceived stress scale (PSS) before and following the intervention. The scale uses a five-item Likert scale format (never, almost never, sometimes, fairly often, very often) and assesses general distress, and confidence in handling stressful encounters experienced over the past month. Cronbach's **a** was .58, which is similar to previous findings [32].

Statistical Methods—Change in day-time during and after-school, night-time, and 24-hour SBP, DBP, and HR, UNaV, and PSS scores were compared using a series of post-intervention analyses that covaried the respective pre-intervention values (ANCOVAs). When significant, Bonferroni corrected post-hoc analyses compared all groups using the same pre-intervention covariates. All ANCOVA analyses were checked for equality of slopes. ANOVA analyses revealed no significant differences by treatment groups on any pre-intervention values (all *p*s>. 10).

Thirty-eight subjects were excluded from sodium excretion analysis due to either inadequate urinary volume (n=10), low creatinine excretion (n=1 1), or no urine collected (n=17) at either pre or post intervention evaluations. There was no statistically significant differential loss of subjects by group for the urinary data ($X^2 = 1.51$, $p = .47$) and analyses of the UNaV did not differ across the groups at pre-intervention (F[2, 125} = .607 $p = .55$). The final sample analyzed for UNaV consisted of 128 participants: BAM; n = 38, (17 males, 21 females), LST; n = 53 (24 males, 29 females), and HEC; n = 37 (16 males, 21 females). A second set of overnight ambulatory ANCOVA analyses was conducted to determine whether results differed between the subsample and the entire sample of 166 subjects. This time period was chosen because it corresponded to the urine collection period. Utilizing published pediatric data comparing BAM to HEC [23], we confirmed there was at least 80% statistical power to detect UNaV changes for the remaining 128 participants.

RESULTS

Pre-intervention values for all descriptive characteristics, casual SBP, DBP, and HR, SES, family history of EH, and perceived expectancy of benefit are displayed in Table 1. There were no significant differences between the treatment groups on any of these parameters (all *p*s > .10).

Pre-intervention ambulatory BP, UNaV values, and PSS scores, as well as change scores (post – pre intervention) by treatment group, are displayed in Table 2.

To test for effects of schools, 2 (School) by 3 (Intervention) analyses of variance were conducted on the change scores for all dependent measures. No significant school or school by treatment interactions were found (p's > .10).

Ambulatory Systolic Blood Pressure

The ANCOVA models for treatment effect across all time periods of ambulatory SBP were significant (all *p*'s ≤ .05) except for the afterschool period ($p = .07$). For example, a significant treatment difference was found for 24-hour SBP ($F[2, 162] = 5.35$, $p < .01$). Post-hoc analyses comparing intervention groups' average 24-hour SBP change scores revealed several significant differences which are represented via net changes. Net change scores represent the absolute difference in the change scores between two intervention groups adjusted for by the pre-intervention covariate. The BAM group exhibited a significant net change of −3.1±1.0 mmHg (p = .01) compared to LST and −3.1±1.1 mmHg ($p = .02$)

compared to HEC. The largest between-group effects were found during daytime school SBP (F[2, 162] = 5.90, p < .01). Post-hoc analyses revealed a significant net change for BAM when compared to LST (−3.8±1.0 mmHg; p = .01) and to HEC (−4.1±1.4 mmHg; p = .01). Finally, significant group differences were found for nighttime SBP (F[2, 148] = 3.38, p < .04). Post-hoc analyses comparing intervention groups revealed a non-significant net change for BAM compared to LST (−2.8±1.4 mmHg; p = .13) and a significant net change compared to HEC (−3.6±1.5 mmHg; p = .05).

Ambulatory Diastolic Blood Pressure

The ANCOVA model for 24-hour DBP was significant (F[2, 162] = 3.62 p =.03). Post-hoc analyses revealed that BAM compared to LST participants had a significantly greater net reduction in 24-hour DBP (−2.0±0.8 mmHg; p = .03). The net mean difference between BAM and HEC for the 24-hour period was not significant (−1.7±0.9 mmHg; p = . 17). The overall model for daytime DBP during school was significant (F[2,162]= 3.46,p=.03) but post-hoc analyses with Bonferroni correction failed to yield any significant between group differences. The model examining overnight DBP approached significance (F[2,162] = 2.95 p = 06). Changes in daytime after-school and nighttime DBP were not significant.

Ambulatory Heart Rate

ANCOVA models were statistically significant for 24-hour HR (F[2, 162] = 5.11, p < .01) and HR during school hours (F[2, 162] = 7.23, p < .01). Post-hoc analyses of the 24-hour period revealed a significant net change of −3.2 ±1.1 BPM (p = .01) for BAM compared to LST. No significant differences were found between BAM and HEC (p=.06). Post-hoc analyses of daytime HR during school revealed a significant net change when BAM was compared to LST (−5.36±1.5 bpm; p < .01), and when HEC was compared to LST (−3.73 ±1.1 bpm; p = .05). Changes in daytime afterschool and nighttime HR were not significant.

Overnight Sodium Excretion

The ANCOVA model for overnight UNaV approached significance (F[2, 124] = 2.69 p = . 07). After adjusting for pre-intervention levels, participants receiving BAM reduced an average of −.77±.61 mEq/hr, HEC increased by an average of .16±.62 mEq/hr, and LST increased by an average of 1.1±.52 mEq/hr.

Nighttime Ambulatory Measures

A second set of ANCOVA analyses using the subsample that met the criteria for adequate urine was conducted for night time SBP, DBP, and HR. These analyses yielded significant results for all three ambulatory measures (all ps < .05). The pattern of results for this subset of analyses was similar to that observed for the entire sample. Thus, only results of the full sample are presented. For both sets of analyses, BAM participants displayed the greatest reductions on all three hemodynamic measures.

Perceived Stress Scale

Two participants did not complete the PSS at post-intervention (BAM = 1, LST =1). The ANCOVA analysis was completed on the remaining164 participants. No significant group differences in change scores were found.

DISCUSSION

The present study compared effectiveness of BAM, LST, and HEC upon ambulatory BP, and HR, and UNaV among AA adolescents at increased risk for developing CVD. Overall, the BAM intervention outperformed both LST and HEC. For both school and 24-hour SBP, BAM participants showed significant reductions while LST and HEC participants showed little change. BAM participants also showed significantly greater reductions for 24-hour DBP and HR when compared to LST participants, and significantly greater reductions in HR during school when compared to LST.

These findings corroborate and extend previous clinical trials involving normotensive and pre-hypertensive youth [21-23,33]. For example, a school-based three-month program involving Caucasian and AA normotensive middle school students found that BAM reduced daytime after school SBP 2.0 mmHg compared to a HEC group's increase of 3.6 mmHg [33]. A four-month school-based intervention involving AA adolescents with high normal BP revealed that TM resulted in a 4.3 mmHg reduction in daytime SBP compared to a 0.8 decrease for HEC [22]. Another study examined AA ninth graders with high normal SBP and also collected measures on UNaV. Following the three-month intervention, BAM participants showed a nighttime SBP reduction of 4.3 mmHg and a reduction in overnight UNaV of 0.4 mEq/hr compared to control participants who showed a decrease of 0.9 mmHg for SBP and an increase of 1.0 mEq/hr for UNaV [23]. The present study enabled comparisons of not only meditation and health education control but also a cognitive behavioral intervention upon ambulatory function, as well as sodium excretion. BAM resulted in significant reductions in daytime, night-time and 24-hour SBP ranging from 2.8 to 3.7 mmHg and UNaV decreases of $-.77 \pm .61$ mEq/hr compared to little change among the LST and HEC groups.

Although LST subjects showed little or no change for ambulatory BP, they tended to increase their ambulatory HR levels. For example, LST showed a significant increase of 1.7 bpm during school-time compared to decreases of 3.1 and 1.5 bpm for the BAM and HEC groups, respectively. A possible explanation for lack of efficacy with LST is that training requires the entire 12 weeks to develop the assorted coping skills and by post intervention they would have had limited time to practice and implement these new skills. In addition, LST participants may have been experiencing greater SNS arousal during the monitoring due to anxiety associated with trying to implement their new coping techniques. The other interventions are faster in concept development. BAM participants learn the technique within 1-2 days and HEC involves exposure to lifestyle changes that can be made early on (e.g. increased physical activity). Future studies involving LST may benefit from a longer training period and additional opportunities to practice the newly acquired behavioral skills. Physical activity interventions have shown BP reductions via weight reduction [34-36]. Inclusion of school-wide changes in nutrition and physical exercise programs in combination with BAM may help magnify improvements in BP control.

Lack of evaluation of frequency and perceived severity of stressful interpersonal exchanges experienced by subjects during the ambulatory monitoring is a limitation. This information would be particularly useful with the LST participants to determine how well they implemented the various cognitive behavioral coping skills and whether they experienced increased stress levels when doing so and/or subsequent worry and ruminations which have been shown to prolong stress-activated physiological arousal [37]. Future studies would benefit from repeated 24-hour monitoring and inclusion of measures of stress exposures, perceived severity ratings, affective and cognitive sequale, coping strategies utilized, etc. via electronic technologies (e.g. PDAs, smartphones, iPods) [38].

The present study is one of the first to examine impact of behavioral interventions upon UNaV. BAM participants exhibited greater reductions in overnight UNaV compared to the HEC and LST groups. Increased levels of SNS activity produce an increased release of hormones such as aldosterone II which increase sodium appetite, as well as increasing sodium re-absorption [12]. The study did not measure sodium intake preventing the ability to distinguish whether participants decreased sodium intake or changed their sodium re-absorption. However, increases in sodium re-absorption typically lead to increases in BP and given the decreased overnight UNaV and associated improvement in ambulatory hemodynamic function noted among BAM participants, it suggests that SNS activity was decreased and a reduction in sodium intake occurred [12].

Despite the study limitations, BAM participants displayed the largest decreases across ambulatory BP and HR measures and evidenced greater decreases in overnight UNaV compared to HEC and LST. Additional research is required to determine whether hemodynamic function improvements from BAM are sustained and whether benefits from LST start manifesting after completion of the program. Such information will determine whether BAM and/or LST could become viable non-pharmacologic low cost primary prevention approaches in public schools, churches, recreation centers, etc., as part of our efforts to help decrease cardiovascular morbidity and mortality.

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Glossary

AA	African American
BAM	breathing awareness meditation
BP	blood pressure
CVD	cardiovascular disease
DBP	diastolic blood pressure
EH	essential hypertension
HEC	health education control
HR	heart rate
LST	LifeSkills® Training
PSS	perceived stress scale
SBP	systolic blood pressure
SES	socioeconomic status
SNS	sympathetic nervous system
UNaV	urinary sodium excretion rate

References

1. World Health Organization. The World Health Report 2007: A safer future: global public health security in the 21st century. World Health Organization; Geneva, Switzerland: 2007.
2. Hertz RP, Unger AN, Cornell JA, et al. Racial disparities in hypertension prevalence, awareness, and management. Arch Intern Med 2005;165(18):2098–2104. [PubMed: 16216999]

3. Rosamond W, Flegal K, Furie K, et al. Heart diease and stroke statistics--2008 update: a report from the American Heart Association statistics committee and stroke statistics subcomittee. Circulation 2008;117(4):e25–146. [PubMed: 18086926]
4. Muntner P, He J, Cutler JA, et al. Trends in blood pressure among children and adolescents. JAMA 2004;291(17):2107–2113. [PubMed: 15126439]
5. Sorof JM, Lai D, Turner J, et al. Overweight, ethnicity, and the prevalence of hypertension in school-aged children. Pediatrics Mar;2004 113(3 Pt 1):475–482. [PubMed: 14993537]
6. Kannel WB, Vasan RS, Levy D. Is the relation of systolic blood pressure to risk of cardiovascular disease continuous and graded, or are there critical values? Hypertension Oct;2003 42(4):453–456. [PubMed: 12975387]
7. Dekkers JC, Snieder H, Van den Oord EJCG, et al. Moderators of blood pressure development from childhood to adulthood: A 10-year longitudinal study in African- and European American youth. Journal of Pediatrics 2002;141:770–779. [PubMed: 12461492]
8. Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents: a working group report from the National High Blood Pressure Education Program. National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents. Pediatrics Oct;1996 98(4 Pt 1):649–658. [PubMed: 8885941]
9. Manatunga AK, Jones JJ, Pratt JH. Longitudinal assessment of blood pressures in black and white children. Hypertension Jul;1993 22(1):84–89. [PubMed: 8319996]
10. Sparrenberger F, Cichelero FT, Ascoli AM, et al. Does psychosocial stress cause hypertension? A systematic review of observational studies. J Hum Hypertens Jan;2009 23(1):12–19. [PubMed: 18615099]
11. Folkow B. Psychosocial and central nervous influences in primary hypertension. Circulation Jul; 1987 76(1 Pt 2):I10–19. [PubMed: 3297391]
12. Walton KG, Pugh ND, Gelderloos P, et al. Stress reduction and preventing hypertension: preliminary support for a psychoneuroendocrine mechanism. J Altern Complement Med Fall;1995 1(3):263–283. [PubMed: 9395623]
13. Bourjeili N, Turner M, Stinner J, et al. Sympathetic nervous system influences salt appetite in four strains of rats. Physiol Behav Sep;1995 58(3):437–443. [PubMed: 8587949]
14. Jeong EY, Kim KN. Influence of stress on snack consumption in middle school girls. Nutr Res Pract Winter;2007 1(4):349–355. [PubMed: 20368961]
15. Guyton AC. Renal function curve--a key to understanding the pathogenesis of hypertension. Hypertension Jul;1987 10(1):1–6. [PubMed: 3596763]
16. Weinberger MH, Miller JZ, Luft FC, et al. Definitions and characteristics of sodium sensitivity and blood pressure resistance. Hypertension Jun;1986 8(6 Pt 2):II127–134. [PubMed: 3522418]
17. Weinberger MH. Salt sensitivity of blood pressure in humans. Hypertension Mar;1996 27(3 Pt 2): 481–490. [PubMed: 8613190]
18. Dickinson HO, Campbell F, Beyer FR, et al. Relaxation therapies for the management of primary hypertension in adults: a Cochrane review. J Hum Hypertens. Jun 12;2008
19. Ospina MB, Bond K, Karkhaneh M, et al. Clinical trials of meditation practices in health care: Characteristics and quality. J Altern Complement Med 2008;14(10):1199–1213. [PubMed: 19123875]
20. Rainforth MV, Schneider RH, Nidich SI, et al. Stress reduction programs in patients with elevated blood pressure: a systematic review and meta-analysis. Curr Hypertens Rep Dec;2007 9(6):520–528. [PubMed: 18350109]
21. Barnes VA, Treiber FA, Davis H. Impact of Transcendental Meditation on cardiovascular function at rest and during acute stress in adolescents with high normal blood pressure. J Psychosom Res Oct;2001 51(4):597–605. [PubMed: 11595248]
22. Barnes VA, Treiber FA, Johnson MH. Impact of Transcendental Meditation on ambulatory blood pressure in African-American adolescents. Am J Hypertens Apr;2004 17(4):3 66–3 69.
23. Barnes VA, Pendergrast RA, Harshfield GA, et al. Impact of breathing awareness meditation on ambulatory blood pressure and sodium handling in prehypertensive African American adolescents. Ethnicity and Disease Winter;2008 1 8(1):1–5. [PubMed: 18447091]

24. Botvin GJ, Griffin KW. Life skills training as a primary prevention approach for adolescent drug abuse and other problem behaviors. Int J Emerg Ment Health Winter;2002 4(1):41–47. [PubMed: 12014292]

25. Kabat-Zinn, J.; Hanh, TN. The Program of the Stress Reduction Clinic at the University of Massachusetts Medical Center. Delta; New York: 1990. Full Catastrophe Living: Using the Wisdom of your Body and Mind to Face Stress, Pain and Illness.

26. O'Brien E, Staessen J. Normotension and hypertension defined by 24-hour ambulatory blood pressure monitoring. Blood Press Sep;1995 4(5):266–282. [PubMed: 8535548]

27. O'Brien E, Mee F, O'Malley K. Accuracy of the Spacelabs 90207 determined by the British Hypertension Society protocol. Am J Hypertens 1991;9(6):573–574.

28. Harshfield GA, Wilson ME, Hanevold C, et al. Impaired stress-induced pressure natriuresis increases cardiovascularload in African American youths. Am J Hypertens Oct;2002 15(10 Pt 1): 903–906. [PubMed: 12372678]

29. Remer T, Neubert A, Maser-Gluth C. Anthropometry-based reference values for 24-h urinary creatinine excretion during growth and their use in endocrine and nutritional research. Am J Clin Nutr Mar;2002 75(3):561–569. [PubMed: 11864864]

30. Sullivan JM, Ratts TE, Taylor JC, et al. Hemodynamic effects of dietary sodium in man: a preliminary report. Hypertension Jul-Aug;1980 2(4):506–514. [PubMed: 6995291]

31. Hollingshead, AB. Four factor index of social status. Department of sociology, Yale University; New Haven, Conn: 1981.

32. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav Dec;1983 24(4):385–396. [PubMed: 6668417]

33. Barnes VA, Davis HC, Murzynowski JB, et al. Impact of meditation on resting and ambulatory blood pressure and heart rate in youth. Psychosom Med Nov-Dec;2004 66(6):909–914. [PubMed: 15564357]

34. Danforth JS, Allen KD, Fitterling JM, et al. Exercise as a treatment for hypertension in low-socioeconomic-status black children. J Consult Clin Psychol Apr;1990 58(2):237–239. [PubMed: 2335640]

35. Ewart CK, Young DR, Hagberg JM. Effects of school-based aerobic exercise on blood pressure in adolescent girls at risk for hypertension. Am J Public Health Jun;1998 88(6):949–951. [PubMed: 9618627]

36. Hagberg JM, Goldring D, Ehsani AA, et al. Effect of exercise training on the blood pressure and hemodynamic features of hypertensive adolescents. Am J Cardiol Oct 1;1983 52(7):763–768. [PubMed: 6624669]

37. Brosschot JF, Gerin W, Thayer JF. The perseverative cognition hypothesis: a review of worry, prolonged stress-related physiological activation, and health. J Psychosom Res Feb;2006 60(2): 113–124. [PubMed: 16439263]

38. Brondolo E, Rieppi R, Erickson SA, et al. Hostility, interpersonal interactions, and ambulatory blood pressure. Psychosom Med Nov-Dec;2003 65(6):1003–1011. [PubMed: 14645779]

Table 1

Baseline anthropometric characteristics

Characteristic	BAM (n=53)	LST (n=69)	HEC (n=44)
Age (years)	15.07±0.70	14.98±0.71	15.12±0.85
Sex (male/female)	21/32	30/39	17/27
Weight (kg)	70.04±20.87	71.33±21.63	71.15±23.26
Height (cm)	164.84±8.37	166.61±8.84	164.78±7.76
BMI (kg/m^2)	25.68±6.87	25.56±6.93	25.99±7.46
Casual SBP	117.31± 7.51	119.90±8.27	119.20±5.99
Casual DBP	64.95±14.44	63.08±6.39	62.80±5.01
Casual HR	78.31±11.02	80.19±10.35	80.50±15.62
SES	36.54±12.83	34.32±14.16	31.39±11.38
Expectancy of benefit	1.81±.97	1.99±1.06	2.22±.93
Hypertensive Parent (one)	18%	47%	32%
Hypertensive Parents (both)	12%	10%	5%

BAM=breathing awareness meditation; LST= LifeSkills® Training; HEC= health education control, SBP=systolic blood pressure, DBP=diastolic blood pressure, HR=heart rate, BMI=body mass index, SES =socio-economic status; measured by Hollingshead index, No significant differences were found between groups on any baseline characteristics ($p > .10$).

Table 2

Mean pre– and post–pre intervention values for ambulatory systolic and diastolic blood pressure, and heart rate, and sodium excretion rate

	BAM (n=53)		LST (n=69)		HEC (n=44)	
SBP	Pre	ΔPost-Pre	Pre	ΔPost-Pre	Pre	ΔPost-Pre
During School*12	124.5±8.5	−3.7±0.5	124.9±7.4	0.0±0.0	125.9±7.3	−0.1±1.0
After School	122.9±7.5	−2.8±0.9	122.6±7.1	0.0±0.9	125.5±8.1	−0.9±1.0
Nighttime*	111.6±7.6	−2.4±0.8	112.7±8.9	−0.2±1.0	113.2±7.8	−0.1 ±0.4
24-hour*12	119.4±6.4	−2.8±1.1	119.6±6.4	0.2±0.0	121.4±6.5	−0.4±0.9
DBP	Pre	ΔPost-Pre	Pre	ΔPost-Pre	Pre	ΔPost-Pre
During School*	73.7±7.8	−2.4±0.3	74.1±6.6	−0.2±0.3	74.3±6.3	−0.2±0.3
After School	71.7±6.0	−1.7±1.4	71.4±5.8	−.05±0.9	73.0±6.0	−1.1±1.0
Nighttime	60.6±7.7	−2.2±1.2	60.0±7.5	0.7±0.7	61.6±6.8	−0.6±0.2
24–hour*	68.1±5.7	−1.8±0.1	68.0±5.2	0.2±0.1	69.3±5.6	−0.6±0.1
Heart Rate	Pre	ΔPost-Pre	Pre	ΔPost-Pre	Pre	ΔPost-Pre
During School*13	87.3±12.8	−3.1±1.4	86.1±10.3	2.7±1.1	87.5± 12.0	−1.5±3.5
After School	87.2±11.7	−1.2±1.2	85.1±10.8	0.6±0.4	89.2± 10.7	−3.0±0.4
Nighttime	74.4±11.0	−2.1±1.1	74.0±11.7	1.2±0.9	73.4±9.0	−0.9±0.0
24–hour*	82.5±9.9	−1.9±0.8	81.0±8.6	1.8±0.4	82.9±8.8	−1.5±0.0
Perceived Stress	Pre	ΔPost-Pre	Pre	ΔPost-Pre	Pre	ΔPost-Pre
Perceived Stress Scale	6.7±2.8	−0.5±0.0	6.7±3.2	0.0±0.0	7.2±2.7	−0.5±0.3
	BAM (n=38)		LST (n=53)		HEC (n=37)	
Sodium	Pre	ΔPost-Pre	Pre	ΔPost-Pre	Pre	ΔPost-Pre
UNaV	6.2±4.2	−0.9±1.1	6.4±3.6	.9±1.2	5.5±2.8	0.6±0.9

BAM=breathing awareness meditation; LST = Life Skills® Training; HEC= health education control; SBP= systolic blood pressure (mmHg); DBP =diastolic blood pressure (mmHg); Heart rate (bpm); UNaV=overnight urinary sodium excretion rate (mEq/hr); Values are means ± SD.

* represents a significant overall model,

1 significant post–hoc comparisons (Bonferroni adjusted p < .05): 1=BAM vs LST

[2]significant post–hoc comparisons (Bonferroni adjusted $p < .05$): 2=BAM vs HEC

[3]significant post–hoc comparisons (Bonferroni adjusted $p < .05$): 3=LST vs HEC.

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