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

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Article history: Received October 30, 2009; accepted May 20, 2010

Keywords: Adolescents; Ambulatory blood pressure; Breathing awareness meditation; Botvin LifeSkills Training; Clinical trial; Sodium excretion

ABSTRACT

Purpose: To evaluate the effect of breathing awareness meditation (BAM), Botvin LifeSkills Training (LST), and health education control (HEC) on ambulatory blood pressure and sodium excretion in African American adolescents.

Methods: Following 3 consecutive days of systolic blood pressure (SBP) screenings, 166 eligible participants (i.e., SBP > 50th–95th percentile) were randomized by school to either BAM (n = 53), LST (n = 69), or HEC (n = 44). In-school intervention sessions were administered for 3 months by health education teachers. Before and after the intervention, overnight urine samples and 24-hour ambulatory SBP, diastolic blood pressure, and heart rate were obtained.

Results: Significant group differences were found for changes in overnight SBP and SBP, diastolic blood pressure, and heart rate over the 24-hour period and during school hours. The BAM treatment exhibited the greatest overall decreases on these measures (Bonferroni adjusted, ps < .05). For example, for school-time SBP, BAM showed a change of -3.7 mmHg compared with no change for LST and a change of -1.1 mmHg for HEC. There was a nonsignificant trend for overnight urinary sodium excretion (p = .07), with the BAM group displaying a reduction of -1.1 mEq/hr compared with increases of .89 ± 1.2 mEq/hr for LST and .58 ± .9 mEq/hr for HEC group.

Conclusion: BAM appears to improve hemodynamic function and may affect sodium handling among African American adolescents who are at increased risk for development of cardiovascular disease.

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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 with 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 blood pressure (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 50th and 95th percentiles for age and sex (i.e., normotensive to prehypertensive) have an increased risk of developing cardiovascular disease (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 impli-
cated 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 food leads to an increased excretion of sodium as BP increases to restore sodium homeostasis through natriuresis [15]. AAs 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 prehypertensive 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 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 systolic blood pressure (SBP) for TM compared with 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 with a .8 decrease for a control group [22]. In another study, breathing awareness meditation (BAM) was compared with health education controls in AA adolescents with high normal SBP. After 3 months, BAM resulted in greater decreases in 24-hour ambulatory SBP and decreased overnight sodium excretion compared with 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 health education control (HEC) on ambulatory BP and sodium handling among AA adolescents at increased risk for development of CVD.

Methods

Subjects

A total of 1,698 students participating in semester-long 9th grade health education classes were screened over a 4-year period to determine eligibility for participation. Eligibility criteria included having: (1) resting SBP between 50th and 95th percentile for age, height, and sex on 3 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.

A total of 175 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 SDs for entire cohort) and excluded 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 2 measurements were averaged.

Interventions

The 3-month interventions were conducted across two high schools by six health education teachers during their regular health education class periods. Students taking these classes did 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 3-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 3-month intervention (i.e., average of ratings: 3.34 ± .26 for thoroughness; 3.28 ± .32 for class attentiveness; 3.31 ± .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 ps > .05). Statistical differences were observed for attendance between the two schools (77% vs. 90%, p = .01). These differences were primarily because several of the cohorts in one of the schools were 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 exercise is 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. Sessions of 10-minute duration 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**

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**

Weekly health education lessons consisted of 50-minute sessions on CV health-related lifestyle behaviors based on 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 after the intervention, ambulatory SBP, diastolic blood pressure (DBP), and heart rate (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 AM–3 PM), after school (3 PM–10 PM), nighttime (12 AM–7 AM), and 24-hour periods. No more than 2 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; 5th 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 preintervention, information was collected on age, sex, family history of essential hypertension, and socioeconomic status (SES) using the Hollingshead social status index [31]. Expectation of health benefits was assessed with 3 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 5-item Likert scale was used (not at all, a little, somewhat, a lot, very much). The 3 questions were summed. Cronbach’s α 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 after the intervention. The scale used a 5-item Likert scale format (never, almost never, sometimes, fairly often, very often) and assessed general distress and confidence in handling stressful encounters experienced over the past month. Cronbach’s α was .58, which is similar to previous findings [32].

**Statistical methods**

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

Thirty-eight subjects were excluded from sodium excretion analysis because of either inadequate urinary volume (n = 10), low creatinine excretion (n = 11), or no urine collected (n = 17) at either pre or postintervention evaluations. There was no statistically significant differential loss of subjects by group for the urinary data (χ² = 1.51, p = .47) and analyses of the UNaV did not differ across the groups at preintervention (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 period was chosen because it corresponded to the urine collection period. Using published pediatric data comparing BAM to HEC [23], we confirmed that there was at least 80% statistical power to detect UNaV changes for the remaining 128 participants.

**Results**

Preintervention 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 ps > .10).

Preintervention 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 was found (ps > .10).

**Ambulatory systolic blood pressure**

The ANCOVA models for treatment effect across all periods of ambulatory SBP were significant (all ps ≤ .05) except for the
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 with LST (−3.8 ± 1.0 mmHg; p = .01) and 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 nonsignificant net change for BAM compared with LST (−2.8 ± 1.4 mmHg; p = .13) and a significant net change compared with 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 with LST participants had a significantly greater net reduction in 24-hour DBP (−2.0 ± .8 mmHg; p = .03). The net mean difference between BAM and HEC for the 24-hour period was not significant (−1.7 ± .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**

ANOVA 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 with 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

### Table 1

Baseline anthropometric characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>BAM (n = 53)</th>
<th>LST (n = 69)</th>
<th>HEC (n = 44)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>15.07 ± .70</td>
<td>14.98 ± .71</td>
<td>15.12 ± .85</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>21/32</td>
<td>30/39</td>
<td>17/27</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.04 ± 20.87</td>
<td>71.33 ± 21.63</td>
<td>71.15 ± 23.26</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.84 ± 8.37</td>
<td>166.61 ± 8.84</td>
<td>164.78 ± 7.76</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.68 ± 6.87</td>
<td>25.56 ± 6.93</td>
<td>25.99 ± 7.46</td>
</tr>
<tr>
<td>Casual SBP</td>
<td>117.31 ± 7.51</td>
<td>119.90 ± 8.27</td>
<td>119.20 ± 5.99</td>
</tr>
<tr>
<td>Casual DBP</td>
<td>64.95 ± 14.44</td>
<td>63.08 ± 6.39</td>
<td>62.80 ± 5.01</td>
</tr>
<tr>
<td>Casual HR</td>
<td>78.31 ± 11.02</td>
<td>80.19 ± 10.35</td>
<td>80.50 ± 15.62</td>
</tr>
<tr>
<td>SES</td>
<td>36.54 ± 12.83</td>
<td>34.32 ± 14.16</td>
<td>31.39 ± 11.38</td>
</tr>
<tr>
<td>Expectancy of benefit</td>
<td>1.81 ± .97</td>
<td>1.99 ± 1.06</td>
<td>2.22 ± .93</td>
</tr>
<tr>
<td>Hypertensive parent (one)</td>
<td>18%</td>
<td>47%</td>
<td>32%</td>
</tr>
<tr>
<td>Hypertensive parents (both)</td>
<td>12%</td>
<td>10%</td>
<td>5%</td>
</tr>
</tbody>
</table>

BAM = breathing awareness meditation; LST = Life Skills 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

<table>
<thead>
<tr>
<th></th>
<th>BAM (n = 53)</th>
<th>LST (n = 69)</th>
<th>HEC (n = 44)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Δ Post–Pre</td>
<td>Pre</td>
</tr>
<tr>
<td>SBP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During schoola,b</td>
<td>124.5 ± 8.5</td>
<td>−3.7 ± .5</td>
<td>124.9 ± 7.4</td>
</tr>
<tr>
<td>After school</td>
<td>122.9 ± 7.5</td>
<td>−2.8 ± .9</td>
<td>122.6 ± 7.1</td>
</tr>
<tr>
<td>Nighttime*</td>
<td>111.6 ± 7.6</td>
<td>−2.4 ± .8</td>
<td>112.7 ± 8.9</td>
</tr>
<tr>
<td>24-houra,b</td>
<td>119.4 ± 6.4</td>
<td>−2.8 ± 1.1</td>
<td>119.6 ± 6.4</td>
</tr>
<tr>
<td>DBP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During school</td>
<td>73.7 ± 7.8</td>
<td>−2.4 ± .3</td>
<td>74.1 ± 6.6</td>
</tr>
<tr>
<td>After school</td>
<td>71.7 ± 6.0</td>
<td>−1.7 ± 1.4</td>
<td>71.4 ± 5.8</td>
</tr>
<tr>
<td>Nighttime</td>
<td>60.6 ± 7.7</td>
<td>−2.2 ± 1.2</td>
<td>60.0 ± 7.5</td>
</tr>
<tr>
<td>24-houra</td>
<td>68.1 ± 5.7</td>
<td>−1.8 ± 1.1</td>
<td>68.0 ± 5.2</td>
</tr>
<tr>
<td>Heart rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During schoola,c</td>
<td>87.3 ± 12.8</td>
<td>−3.1 ± 1.4</td>
<td>86.1 ± 10.3</td>
</tr>
<tr>
<td>After school</td>
<td>87.2 ± 11.7</td>
<td>−1.2 ± 1.2</td>
<td>85.1 ± 10.8</td>
</tr>
<tr>
<td>Nighttime</td>
<td>74.4 ± 11.0</td>
<td>−2.1 ± 1.1</td>
<td>74.0 ± 11.7</td>
</tr>
<tr>
<td>24-houra</td>
<td>82.5 ± 9.9</td>
<td>−1.9 ± .8</td>
<td>81.0 ± 8.6</td>
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<tr>
<td>Perceived stress</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived stress scale</td>
<td>6.7 ± 2.8</td>
<td>−.5 ± .0</td>
<td>6.7 ± 3.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>BAM (n = 38)</th>
<th>LST (n = 53)</th>
<th>HEC (n = 37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNaV</td>
<td>6.2 ± 4.2</td>
<td>−.9 ± 1.1</td>
<td>6.4 ± 3.6</td>
</tr>
</tbody>
</table>

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.

*a,b,c* Represents a significant overall model, superscripts.

*a,b* Represent significant post hoc comparisons (Bonferroni adjusted p < .05); a = BAM vs. LST, b = BAM vs. HEC, c = LST vs. HEC.
compared with LST (−5.36 ± 1.5 bpm; p < .01) and HEC with LST (−3.73 ± 1.1 bpm; p = .05). Changes in daytime after-school 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 preintervention 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 nighttime 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 3 hemodynamic measures.

**PSS**

Two participants did not complete the PSS at postintervention (BAM = 1, LST = 1). The ANCOVA analysis was completed on the remaining 164 participants. No significant group differences in change scores were found.

**Discussion**

The present study compared effectiveness of BAM, LST, and HEC on ambulatory BP, 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 as compared with LST and HEC participants. BAM participants also showed significantly greater reductions for 24-hour DBP and HR when compared with LST participants, and significantly greater reductions in HR during school when compared with LST.

These findings corroborate and extend previous clinical trials involving normotensive and prehypertensive youth [21–23,33]. For example, a school-based 3-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 4-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 with a .8 decrease for HEC [22]. Another study examined AA 9th graders with high normal SBP and also collected measures on UNaV. After the 3-month intervention, BAM participants showed a nighttime SBP reduction of 4.3 mmHg and a reduction in overnight UNaV of .4 mEq/hr compared with control participants who showed a decrease of .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, nighttime, and 24-hour SBP ranging from 2.8 to 3.7 mmHg and UNaV decreases of −.77 ± .61 mEq/hr compared with 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 with 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 because of 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 through 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 promote 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 sequela, coping strategies used, through electronic technologies (e.g., PDAs, smartphones, iPods) [38].

The present study is one of the first to examine the effect of behavioral interventions on UNaV. BAM participants exhibited greater reductions in overnight UNaV compared with 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 with 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 nonpharmacologic low cost primary prevention approaches, such as in public schools, churches, recreation centers, as part of our efforts to help decrease cardiovascular morbidity and mortality.
Acknowledgments

We would like to thank Dr. D. Bedden (current) and Dr. C. Larke (former), Superintendents; teachers and staff at Richmond County Public High Schools for their assistance and cooperation in providing the facilities for this study. We also gratefully acknowledge the following research assistants who assisted with data gathering and other aspects of the study. Greg Slavens and Shawntel Parker assisted with data management and analysis. Research assistants who assisted with data collection were Bridgitt Wells, Brenda Jackson, Sandra Young-Mayes, Tracy Miller, and Pam Shields. This study was supported by R01 Grant #.

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