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Influences of Family Environment and Meditation Efficacy on Hemodynamic Function among African American Adolescents*

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Abstract

This study examined the impact of breathing awareness meditation (BAM) compared to health education (HE) and lifeskills training (LS) upon resting systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) within the context of potential moderating factors of family environment and expectancy of benefit. 186 African American adolescents (mean age: 15.1±0.7 yrs) were randomly assigned by school to three-month BAM, LS, or HE interventions. Laboratory resting blood pressure (BP), Family Relations Index (FRI) and expectancy of benefit evaluations were conducted at pre- and post-intervention. Higher expectancy of benefit from any of the three interventions resulted in greater reductions in SBP. A two-way interaction indicated that BAM group subjects who came from positive family environments exhibited greater decreases in SBP. A two-way interaction indicated that BAM and LS subjects who came from positive family environments exhibited greater DBP decreases. A two-way interaction indicated that BAM subjects who came from positive family environments exhibited a greater HR decrease (all $p<.05$). Expectancy of intervention benefits beneficially impacted success of behavioral interventions aimed at reducing SBP. Positive family environments in combination with either BAM or LS appear to have a beneficial impact upon hemodynamic function in AA adolescents.

Keywords

blood pressure; African American; adolescents; meditation; moderating factors

INTRODUCTION

The incidence of pediatric hypertension has been escalating over the past decade (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004) with higher incidence reported among minority adolescents, such as African Americans (AAs), compared to non-Hispanic Whites (Muntner et al., 2004). Blood pressure (BP) rankings track from late childhood into adulthood (Chen

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and Wang, 2008) and AA children show statistically higher tracking when compared to Whites (Kelder et al., 2002). Associations have been shown between BP and sub-clinical cardiovascular disease (CVD) in youth (Berenson et al., 1998) and it has been hypothesized that early life elevated BP increases CVD risk (McCarron et al., 2002). Environmental stress-related factors (e.g., aversive interpersonal interactions related to socioeconomic status inequality, racism, neighborhood and/or family dysfunction) have been implicated in the development of essential hypertension (EH) (Anderson, 1989; Williams et al., 1997; Clark et al., 1999). Given the potential role of psychosocial stress in the development of EH, there is a need for development of effective and easily disseminated EH primary prevention programs (Baranowski et al., 2002).

Few BP-related stress reduction interventions have been conducted in youth; however, findings are promising (Black et al., 2009). A school-based, daily progressive muscle relaxation program conducted for four months in adolescents with high normal BP showed a significant decrease in SBP compared to a waiting list control condition (Ewart et al., 1987). Using meditation as a stress reduction technique, a randomized clinical trial (RCT) in AA adolescents with high-normal BP (>85th and <95th percentile range) found that after two and four month interventions, Transcendental Meditation® significantly lowered resting SBP/DBP and daytime ambulatory SBP/DBP compared to health education (HE) controls (Barnes et al., 2001; Barnes et al., 2004). A study with normotensive middle school students practicing breathing awareness meditation (BAM) reported greater decreases in resting SBP, daytime ambulatory systolic BP (SBP) and heart rate (HR) compared with a health education (HE) control group (Barnes et al., 2004). A three-month RCT comparing BAM to health education (HE) control group among AA youth with high-normal SBP (>75th and <95th percentile range) found that BAM resulted in significantly greater decreases in ambulatory daytime SBP and HR and nighttime SBP (Barnes et al., 2008). Health education (HE) involved comparable teacher exposure time and included information on CV health-related lifestyle behaviors. As in other studies, HE did not significantly reduce BP in AA adolescents (Barnes et al., 2004; Barnes et al., 2007).

Ineffective stress-related coping skills (Gleiberman, 2007), anger management problems (Harburg et al., 1991) and high hostility (Burns et al., 2006) have been associated with EH (Jorgensen and Kolodziej, 2007). Botvin's Life Skills (LS) Program, a multimodal cognitive-behavioral program, has not been tested with regard to impact upon BP control (Botvin and Eng, 1982). LS has been found to facilitate development of important cognitive-behavioral skills for managing stress and anger, increasing self-esteem, decreasing anxiety and general stress, and improving stress-related coping skills (Botvin et al., 1980; Botvin et al., 1984; Botvin and Griffin, 2002).

Effectiveness of behavioral approaches for prevention of EH may be partially dependent upon tailoring within the context of the individual's preexisting environmental background moderating factors. Two important factors include expectancy of intervention benefit and family support and functioning. For example, a previous pediatric study found maladaptive family environment to be predictive of increased resting BP values (Clark and Armstead, 2000). A number of studies have found family relations to be associated with hemodynamic functioning. Luecken *et al.* found that young adults' retrospective recalls of childhood revealed that those who reported adaptive, nurturing family environments exhibited greater SBP recovery to a speech stressor (Luecken et al., 2005). Family conflict was shown to predict mean resting BP changes across six months among AA adolescents (Clark and Armstead, 2000). Increased family cohesion has been associated with parental report of decreased child-rearing-related stress (Anderson, 2008) and increased adherence to treatment regimens among adolescents with chronic diseases (Pereira et al., 2008). Other studies that involved Family Environment Scale (FES) cohesion, conflict or expression

subscales and hemodynamic function in youth have shown associations with the offspring's mean arterial pressure, SBP, and total peripheral resistance at rest and/or in response to various behavioral stressors (Wright et al., 1993; Musante et al., 1996).

Studies have assessed subjects' expectancies of benefit from various interventions (e.g., surgery, physical rehabilitation programs) upon recovery from a range of clinical conditions such as myocardial infarction, cardiac surgery, and chronic pain (Myers et al., 2008). Higher expectations for recovery have been shown to be associated with greater functional improvement compared with those with low expectation. For example, improved function and reduced lower back pain has been observed among participants who expressed high versus those who expressed low benefit expectations from massage or acupuncture treatment and who received such interventions in an RCT (Kalauokalani et al., 2001).

The current study is an effort to compare the effectiveness of three behavioral interventions on BP reduction in youth within the context of family environments and belief of outcome for type of treatments received. We hypothesized that better family functioning and greater expectation of benefit would play pivotal roles in enhancing the success of behavioral interventions, especially with interventions practiced at home. Specifically, the present study examined the impact of BAM, LS, and HE upon resting SBP, DBP and heart rate (HR) in AA adolescents at increased risk for development of CVD.

METHODS

Participants

The Human Assurance Committee of the Medical College of Georgia approved this study. The research was conducted in two Augusta, Georgia high schools. A total of 240 AA high school students were identified from 1767 screened over a four-year (Fall 2004 to Spring 2008) period as meeting eligibility for participation in the study. Eligibility criteria included having: (1) resting SBP between 50th to 95th percentile for age, height and gender on three consecutive school days; (2) no history of congenital heart defect, diabetes, sickle cell anemia, asthma, or any chronic illness or health problem that requires regular pharmacological treatment; (3) not currently involved, or planning to engage in a formal exercise or health promotion program including organized individual or team sports; (4) willingness to accept randomization into treatment groups; (5) AA or Black, based on parental report; (6) weight less than 275 pounds; and (7) not pregnant.

Prior to randomization, 41 subjects were excluded due to either moving out of the area, or school scheduling conflicts. Written informed consent was obtained by the Principal and Co-Investigators (F.A.T, V.A.B), and research assistants for the remaining 199 subjects. These were randomly assigned by school to treatment group by a blinded biostatistician. Treatment groups were subsequently counterbalanced (alternated) across time and schools. Eighteen subjects were excluded from the analysis due to lack of posttest data. There was no differential loss of subjects to follow-up by treatment group ($p>.05$) and no adverse events were reported that were attributed to the interventions. The final sample of 186 consisted of 56 BAM (20M, 36F), 72 LS (31M, 41F), 58 HE (24M, 34F) subjects. All testing personnel were blind to the treatment assignment.

Screening Procedure

Height was measured by stadiometer and weight by Detecto CN20 scale (Cardinal Scale Manufacturing Co., Webb City, MO). Seated resting SBP, DBP and HR measures during initial screenings for study inclusion were recorded four times over 10 minute periods (0, 5, 7, 9 minutes) on three consecutive days at school using Dinamap 1846SX monitors

(Critikon, Inc., Tampa, FL). The first measurement each day was discarded and the other 3 measurements averaged.

Behavioral Interventions

The behavioral interventions were conducted by high school health education teachers during their regular class periods. Teachers received time-matched training for the intervention they were randomly assigned to teach. Each teacher was certified as being competent to teach by the instructors (VAB and MST). Due to the nature of the interventions, neither the participants nor those administering the interventions were blind to treatment assignment. Qualitative and quantitative assessments of the teachers' implementation of their assigned interventions were conducted by a research assistant on a weekly basis. Using Likert scale ratings (0–4 scale) of thoroughness, class attentiveness, and enthusiasm, instructors were rated for competence in implementing the various components of the interventions throughout the three-month behavioral interventions (i.e., average of ratings across all three interventions: 3.34±0.26 for thoroughness; 3.28±0.32 for class attentiveness; 3.31±0.27 for enthusiasm).

Breathing Awareness Meditation—BAM is exercise one of the Mindfulness-Based Stress Reduction Program (Kabat-Zinn and Hanh, 1990). Practice involves sustaining attention on the breathing process and passively observing thoughts. The individual sits upright in a comfortable position with eyes closed and focuses on diaphragm movements while breathing in a slow, deep, relaxed manner. Ten-minute BAM sessions were prescribed at school and home each day. Average in-school attendance for participants receiving the BAM treatment was 81% of total sessions. Self-reported compliance for BAM home practice was 86.6% of total practice opportunities (i.e. once daily on school days and twice daily on weekends).

Life Skills Training—Weekly 50-minute LS sessions, developmentally and age-appropriate for ninth grade students, involved selected components of Botvin's LifeSkills Program: Group discussions, passive and active modeling, behavioral rehearsal, feedback, reinforcement and behavioral homework assignments (Botvin and Griffin, 2002). The selected program components provided training in problem-solving skills, reflective listening, conflict resolution, anger management to enhance social skills, assertiveness, and personal and social competence (Botvin et al., 1984; Botvin, 2004). Average in-school attendance for members receiving the LS group treatment was 85% of total sessions.

Health Education (HE)—As a control condition, weekly 50-min HE sessions on CV health-related lifestyle behaviors were conducted based upon the National Heart, Lung, and Blood Institute (NHLBI) guidelines for youth. Sessions included brochure handouts, videotapes, discussions and recommendations for increasing physical activity (e.g., walking, sports), and establishing and maintaining prudent nutrition (e.g., reducing fat consumption). In-school average attendance for members receiving HE treatment was 80% of total sessions. No relaxation or stress reduction techniques were given to the LS or HE groups.

Resting Laboratory Hemodynamics

Outcome variables were SBP, DBP and HR during supine rest periods measured at pre- and post-intervention. At each of these evaluations, resting hemodynamic data were recorded three times every two minutes following a 10-minute rest using established protocols (Treiber et al., 1993; Dysart et al., 1994) with Dinamap Vital Signs Monitors 1846SX (Wattigney et al., 1996). The Dinamap has been validated (Whincup et al., 1992) for use in pediatric research (Park and Menard, 1987). The averages of the last two readings collected during each evaluation were used in the statistical analyses. Differences in resting

hemodynamics between groups were tested at pre-intervention. No significant between group effects were found (p>.05).

Moderating Variables

The Family Relations Index (FRI) from the Family Environment Scale (55) contains three, 10-item subscales that assess: 1) Cohesion: the extent to which family members support one another; 2) Emotional expressiveness: the degree to which family members express their feelings; and, 3) Conflict: the extent to which the family experiences disagreements. The one-year test-retest reliability is 0.66 (55). The FRI is a composite score representing the degree of adaptive family functioning (i.e., cohesion plus expression minus conflict). The FRI was selected because the three subscales have collectively been associated with various indices of stress and/or hemodynamic functioning in youth (Woodall and Matthews, 1989; Wright et al., 1993; Musante et al., 1996; Clark and Armstead, 2000).

Expectation of health benefits was assessed with a series of three questions adapted for this study (one series for each intervention) to determine expectation that HE, BAM, and LS programs would be effective in lowering BP, improving overall health, mental health and well-being. A composite score was derived by totaling scores for the three questions for each intervention. A five-item Likert scale (not at all, a little, somewhat, a lot, very much) was used. Cronbach alpha internal consistency statistics for the three questions were 0.72 for HE, 0.81 for BAM and 0.85 for LS.

Analytic Approach

In addition to examining the effects of type of intervention upon hemodynamic function, the moderating influence of pre-intervention report of family functioning (FRI) and perceived expectation of benefit from treatment were also examined. Median splits were created for both the FRI scores and perceived expectation of treatment benefits scores that distinguished scores at or above the median versus those below the median. A series of 3 (intervention group) X 2 (FRI) X 2 (perceived expectation of benefit) analyses of variance were conducted using the resting hemodynamic change score (post-test minus pre-test) as the dependent measure. When significant interactions occurred, additional *post-hoc* comparison analyses using Tukey's honest significance test with Bonferroni adjustments were conducted. The interaction for sex by treatment group was initially examined for changes in resting SBP, DBP and HR. The interactions of sex by treatment group were all non-significant (all p's > 0.05) and therefore sex was excluded from subsequent analyses.

RESULTS

Demographic and anthropometric characteristics of the subjects at pre- and post-intervention are presented in Table 1.

As expected, statistically significant changes in age, height, weight, waist circumference, body mass index (BMI), SBP and DBP were observed across the three-month study period (all ps<0.05). However, no between-group differences were found for any anthropometric characteristics (all ps>.05). No between-group differences were found in percent attendance at school sessions among treatment groups (p>.05).

For changes in SBP, a statistically significant main effect was observed for expectancy of treatment benefit (F[1, 173]=4.47, p=.04). Irrespective of intervention treatment, participants who were at or above the median for expectancy of treatment benefit for the intervention received had an average decrease of 1.4 mmHg in SBP compared to an average increase of 0.95 mmHg if they reported expectancy of benefit below the median. This is an absolute difference of 2.35 mmHg between higher vs. lower expectancy of treatment benefits. A

significant interaction was noted involving intervention treatment and Family Relations Index (FRI) ($F[2, 173]=4.05$, $p=.02$). As shown in Table 2, participants that received BAM and reported a FRI on or above the median at pre-intervention had the greatest reduction in resting SBP (−3.27 mmHg, $p<.05$).

To reduce the number of family-wise comparisons, *post hoc* analyses were conducted comparing this subgroup to the five other subgroups. Findings revealed that the BAM/high FRI subgroup exhibited significantly greater reductions in resting SBP compared with subgroups BAM/low FRI, HE/high FRI, and LS/low FRI (range= −0.5 to 2.2 mmHg, all $ps<.05$). Although not reaching statistical significance for three-way interaction effects, BAM subjects reporting both higher FRI and higher expectancy of benefits from BAM showed the largest reduction in SBP compared to all other subgroups (−5.3 mmHg, *p=ns*).

The results for change in resting DBP revealed a significant two-way interaction involving intervention treatment and FRI ($F[2,173]=3.88$, $p<.03$). Subsequent *post hoc* comparison analyses revealed that participants that received BAM or LS and who also reported higher FRI scores (on or above the median) had average reductions of 2.82 mmHg and 2.39 mmHg, respectively, which were each significantly lower than the subgroups of HE/high FRI and BAM/low FRI (0.69 and 1.04 mmHg, $ps<.05$).

Finally, the analyses of HR revealed a significant interaction for intervention treatment by FRI ($F[2,170]=3.28$, $p=.04$). *Post hoc* analyses indicated that participants who received BAM and reported high FRI scores had a significant reduction in HR of 1.80 bpm compared to increases in the LS/high FRI (2.48 bpm), HE/high FRI and BAM/low FRI subgroups (range of 1.39 to 2.48 bpm, $ps<.05$).

DISCUSSION

This study compared the effectiveness of a meditation technique (i.e., BAM), a cognitive behavioral intervention (LS) and health education (HE) upon resting hemodynamic function in AA youth at increased risk for development of CVD. We examined two background characteristics that could impact the likelihood of benefit from the three-month interventions, namely family functioning and perceived expectancy of benefits from participation in the treatment programs. The main findings were that, irrespective of type of intervention, higher expectation of beneficial effects (i.e., decreased BP and improved mental health and well-being) resulted in significant decreases in resting SBP. In addition, self-report of higher family functioning had particularly beneficial effects upon improvements in resting blood pressure (i.e., SBP and DBP) for BAM and LS participants. This beneficial moderation effect was also observed for HR among those who practiced BAM. BAM subjects from more cohesive and supportive family backgrounds who also expected positive benefits from participating in BAM exhibited the greatest reduction in SBP compared to the other subgroups. These findings add to the literature the benefit of non-pharmacological methods in resting hemodynamics as a function of intervention, family functioning and expectation of benefit.

Expectancy or perceived likelihood of treatment effects has been shown to have a significant impact upon treatment outcomes in interventions involving adults (Kalauokalani et al., 2001; Stewart-Williams, 2004; Myers et al., 2008; Price et al., 2008), mainly in trials involving treatment of pain (Hróbjartsson and Gøtzsche, 2001). The present findings extend this literature by involving adolescents and inclusion of meditation and cognitive behavioral lifeskills training beneficially influenced by expectancy. While we have presented evidence that expectation of benefit can have an important effect on outcome, clarifying the mechanism underlying these changes would aid in the development of strategies to reduce

response variability in clinical trials. The concept that expectation of benefit is a moderating factor influencing behavior is supported by evidence that this effect is mediated by specific neural mechanisms (Scott et al., 2008). Findings suggest that specific neural circuits and neurotransmitter systems respond to expectation of benefit, which in turn are associated with measurable physiological and affective state changes (de la Fuente-Fernández et al., 2001; Petrovic et al., 2005; Zubieta and Stohler, 2009).

Family functioning has been previously associated with a variety of CVD-related risk factors in youth and adults (Woodall and Matthews, 1989; Hanson et al., 1990; Musante et al., 1990; Wright et al., 1993; Musante et al., 1996). Higher adaptive family relationships during childhood were found to be associated with stronger recovery of SBP following a challenging speech task as an adult (Luecken et al., 2005). This suggests that positive family relationship experiences during childhood continue to have a lasting impact upon hemodynamic functioning into early adulthood. Parental and/or offspring ratings of family cohesion and/or expressiveness via the FRI subscales have been inversely associated with the offspring's mean arterial pressure, SBP, HR and total peripheral resistance at rest and/or in response to various behavioral stressors (Woodall and Matthews, 1989; Wright et al., 1993; Musante et al., 1996; Clark and Armstead, 2000). The present findings extend this literature showing that adaptive and nurturing family environments are associated with greater benefit in adolescents' hemodynamic functioning via meditation and cognitive behavioral lifeskills that are taught at school and designed to be practiced in the home environment. The study demonstrates feasibility conducting such programs in the high school classroom with minimal training required for the school-teacher. The findings suggest that with adolescents, a more nurturing and supportive home environment may provide additional social support to increase likelihood of regular practice, thereby fostering greater benefit from behavioral interventions practiced in the home setting. At home, parents may provide a supportive role by providing free time, reminders for practice and positive reinforcement. Parents may also provide a model for the children and personally benefit by practicing the meditation technique themselves. Adolescents without supportive family factors and resources may not benefit as much from interventions requiring practice in the home environment.

To our knowledge this is the first pediatric study to evaluate the potential moderating influences of pre-existing individual and family-related factors upon BP and HR as a result of participation in a behavioral intervention. Although the present findings are promising they should not be over-interpreted. The current results require replication with a larger sample of AA youth. If replicable patterns are observed in studies with AAs and other ethnic/racial groups, firmer conclusions could be drawn and a greater case for personalized CVD prevention treatment programs in youth could be made. Family background and environmental stress-related factors, expectation of health benefits, etc., would be included in tailoring the type(s) of BP-control-related behavioral interventions potentially most beneficial to the individual. When developing future personalized prevention interventions, consideration would be given for the individuals' preferences and environmental factors, including family, and personal characteristics, prior to behavioral intervention selection. This would increase the likelihood of achieving desired changes in CVD risk factors.

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Table 1

Demographic and Anthropometric Characteristics

Characteristic	Pre-Intervention (n=186)	Post-Intervention
Age (years) *	15.05 (.72)	15.30 (.72)
Height (cm) *	164.66 (8.57)	165.29 (8.64)
Weight (kg) *	68.48 (17.01)	69.53 (17.48)
Waist Circumference (cm) *	79.88 (14.27)	80.77 (14.38)
BMI *	25.20 (5.73)	25.38 (5.78)
SBP (mmHg) *	117.99 (10.07)	116.19 (12.73)
DBP (mmHg) *	62.82 (7.14)	60.73 (11.29)
HR (bpm)	66.43 (9.60)	66.68 (9.64)

Values are mean (±SD). BMI=body mass index. SBP=systolic blood pressure. DBP=diastolic blood pressure. HR=heart rate.

* $p<.05$ for pre to post intervention comparisons

Table 2

Changes in Resting SBP, DBP and HR as a Function of Intervention, and Family Relations Index

Intervention Group		HE	BAM	LS
SBP (mmHg)	Intervention Alone	.838	−.675	−.872
	X Low FRI	−.568	1.91[ac]	−.05[a]
	X High FRI	2.24[ac]	−3.27[bdf]	−1.69[bd]
DBP (mmHg)	Intervention Alone	−.291	−.890	−1.33
	X Low FRI	−1.28[d]	1.04[ace]	−.271
	X High FRI	.694[a]	−2.82[bd]	−2.39[d]
HR (bpm)	Intervention Alone	−.088	−.107	.876
	X Low FRI	−1.56[d]	1.58[ae]	−.727
	X High FRI	1.39[a]	−1.80[bcd]	2.48[a]

SBP=systolic blood pressure. DBP=diastolic blood pressure. HR= heart rate. HE=health education. BAM=breathing awareness meditation. LS=lifeskills training. FRI=Family Relations Index. Low indicates below the median score. High indicates at or above the median score. Superscripts indicate significant within/between group differences p<.05.

[a] BAM/High FRI.

[b] HE/high FRI.

[c] LS/high FRI.

[d] BAM/low FRI.

[e] HE/low FRI.

[f] LS/low FRI.