ORIGINAL COMMUNICATIONS

THE EFFECTS OF CALCIUM SUPPLEMENTATION ON AMBULATORY BLOOD PRESSURE IN AFRICAN-AMERICAN ADOLESCENTS

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This longitudinal trial investigated the effects of calcium supplementation on the mean 24-hour blood pressure in African-American adolescents. Subjects were self-identified African-American adolescents from a high school in a suburb of Los Angeles, California. The subjects were randomly placed in a placebo or treatment group (placebo versus 1.5 g of calcium/day × 4 weeks). Follow-up mean 24-hour ambulatory blood pressure (ABP) for both the treatment and control groups was lower than the baseline mean 24-hour ABP. In the treatment group, there was a decrease of 2.2 mm Hg in the mean systolic blood pressure and 0.7 mm Hg in the diastolic blood pressure. Relative to the placebo group, the net change in ABP was −1.7 mm Hg for systolic blood pressure and −0.5 mm Hg for the diastolic blood pressure. There was no statistically significant effect of calcium supplementation on the 24-hour mean ABP. The net effect of supplementation on ABP during waking and sleeping hours also was not significant. (*J Natl Med Assoc.* 1996;88:774-778.)

Key words • calcium supplementation • blood pressure • African-American adolescents

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The three major risk factors for cardiovascular disease are hypercholesterolemia, smoking, and hypertension. Several epidemiological studies specifically have identified hypertension as an important factor in the incidence of coronary artery disease, cerebral vascular disease and renal disease. There is a significant ethnic difference with reference to the prevalence of hypertension in the United States.[1,2] African Americans are two to four times more likely to develop hypertension by middle age than whites.[3]

Epidemiologic studies report that African Americans have a higher prevalence of hypertension[4] and a lower dietary calcium intake (National Health and Nutrition Examination Survey I [NHANES I]). Studies have shown an association between calcium intake and blood pressure, yet clinical trials have not been convincing. Epidemiological studies also have inversely associated dietary calcium intake with casual blood pressure,[5] although the observations of a clinical trial suggest that calcium supplementation may lower diastolic blood pressure in young people with persistent mild hypertension, especially those with low serum total calcium or high parathyroid hormone.[6] The Bogalusa study reported that the tendency for elevated blood pressure in African Americans begins in childhood. Because hypertensive predisposition appears in childhood and dietary calcium shows a protective relation on blood pressure in epidemiologic studies, the investigation of calcium on ambulatory blood pressure (ABP) in adolescents of African ancestry is warranted.

The study by Liebman et al[7] relating blood pressure to dietary calcium among black and white adolescent females is of particular relevance. An inverse association

between blood pressure and dietary calcium was reported. Black females, in comparison to white females, exhibited higher systolic and diastolic blood pressure, and they reported lower levels of dietary calcium. Furthermore, covariate adjustment for dietary calcium reduced the racial difference in blood pressure. These results are consistent with a model in which dietary calcium has a hypotensive effect among normotensives and in which part of the black-white difference in blood pressure is explained by the lower calcium consumption of blacks.

A trial by Zemel et al[8] yielding suggestive results was conducted among black hypertensives exhibiting salt-sensitivity. Increasing dietary calcium from 356 mg/day to 934 mg/day blunted the hypertensive effect of high levels of dietary sodium (4000 mg/day) in this group. Reductions of −8 mm Hg in systolic blood pressure and −4 mm Hg in diastolic blood pressure were reported with a calcium increase in 14-day crossover metabolic diets. The increase in dietary calcium also blunted salt-induced increases in serum midmolecule parathyroid hormone, urinary cyclic adenosine monophosphate, erythrocyte intracellular calcium and Ca-ATPase activity, and erythrocyte intracellular magnesium. Extrapolating from erythrocytes to smooth muscle, these results suggest that a hypotensive effect of increased dietary calcium among black salt-sensitive hypertensives may operate via calcium-induced suppression of parathyroid hormone or natriuresis. They also suggest that a hypotensive effect of calcium supplementation may be largest among persons with high dietary intakes of sodium. Another clinical study supplying 1400 mg of calcium per day over a 6-week period observed a 10 mm Hg decline in systolic blood pressure in hypertensive males.[9]

While the mechanism by which calcium supplementation lowers blood pressure in some hypertensives and normotensives is not known, the goal of this study was to determine whether ABP is sensitive to oral calcium supplements in some or all black youth with elevated blood pressure. If calcium supplementation enhances membrane stability, then 24-hour ABP is an effective method of blood pressure examination. Ambulatory blood pressure monitoring may elucidate many clinical problems associated with blood pressure better than casual blood pressure. Ambulatory blood pressure monitoring allows the evaluation of blood pressure during daily activities and during sleep. It is therefore a better determinant for borderline hypertension (blood pressure that may be controlled with nonpharmacological intervention), episodic hypertension, white coat hypertension (which occurs when a patient has an elevation in blood pressure only in the physician's office), and episodic hypotension.[10]

Ambulatory blood pressure provides information on the periods when arterial blood pressure is at its peak and nadir. With the use of a detailed diary, correlations can be made between arterial blood pressure and physical activity, mood, and location (home, work, school, etc). Both normotensive and hypertensive African Americans have a smaller decline in their average blood pressure during sleep as stated by Murphy and associates.[11] A significant negative relationship between nighttime blood pressure and creatinine clearance has been found in African-American youth.[12] These results suggest that African-American youth with higher levels of nocturnal blood pressure may have already begun to experience a reduction in renal function, although the values were within normal limits. This may correlate with the increased prevalence of the development of hypertension in the African-American population.

Ambulatory blood pressure measurements also can be used to evaluate the dosage required to lower blood pressure or to evaluate resistant hypertension and episodic hypotension or hypertension.[4] Ambulatory blood pressure also can be used to predict and determine the existence and progression of cardiovascular or systemic disease manifestations. Left ventricular hypertrophy is predominantly secondary to a cardiovascular or systemic disease, such as hypertension.[1,13] One study on ABP in 45 patients with essential hypertension found an absence of nocturnal blood pressure reduction in patients with left ventricular hypertrophy.[13] Sixteen of the 22 patients had no decrease in their blood pressure during sleep.

The observation of this absent decline with the use of ambulatory blood pressure monitoring may predict the development of left ventricular hypertrophy. Until the etiology of essential hypertension is understood, ABP appears to be the most objective method of noninvasive evaluation of blood pressure.

METHODS

A human subject protocol was developed and approved by the Research Committee, University of Southern California, School of Medicine. Written informed parental consent was obtained prior to testing. The subjects were 34 healthy, normotensive, self-identified African-American adolescents, ages 14 to 19 years, recruited from a high school in a Los Angeles suburb.

The ABP unit used in this study was the Space Lab model 90207 (Space Lab Medical, Redmond, Washington.) To determine any malfunction, the ABP unit is calibrated with a mercury manometer prior to placement. The 34 participants were randomly assigned to the treatment or control group. Each group was

TABLE. MEAN AMBULATORY BLOOD PRESSURE (MM HG) BY GROUP

	Daytime*		Nighttime†		24-Hour	
	SBP	DBP	SBP	DBP	SBP	DBP
Treatment group (n=17)						
Baseline	128.3±9.7	93.9±7.3	115.1±8.1	82.1±5.3	126.2±9.1	92.0±6.7
Follow-up	125.9±7.5	93.0±5.5	115.9±12.1	83.9±8.8	124.0±7.0	91.3±4.7
Change‡	−2.39	−0.94	+0.86	+1.88	−2.21	−0.67
Placebo group (n=17)						
Baseline	126.5±8.0	93.9±5.0	113.6±8.7	80.7±6.2	124.0±8.0	90.8±5.0
Follow-up	125.1±6.7	93.0±6.0	115.1±10.9	83.5±8.2	123.5±6.7	90.6±6.0
Change	−1.42	−1.39	+1.46	+2.81	−0.49	−0.18

Abbreviations: SBP=systolic blood pressure and DBP=diastolic blood pressure.
*Daytime is defined as 6:00 AM to 11:00 PM.
†Nighttime is defined as 11:00 PM to 6:00 AM.
‡Change in mean ambulatory blood pressure is defined as follow-up minus baseline.

placed on placebo for 2 weeks to obtain the baseline ABP. The treatment group then received 1.5 g of calcium each day and the control group received placebo daily. The follow-up ABP was measured after 4 weeks. The unit was placed on each participant for 24 hours. Upon placement of the unit, each participant was directed to monitor activities, moods, medication intake, smoking, caffeine intake, and sleeping hours in the provided diary for association with any significant change in the blood pressure reading. The ABP unit measured the blood pressure of each participant every 30 minutes during the day (daytime is defined as 6:00 AM to 11:00 PM) and every 60 minutes during the night (nighttime is defined as 11:00 PM to 6:00 AM)

Data Analysis

The analyses were performed on an IBM computer using SAS software. Group comparisons were performed by a single factor analysis of variance. Means (±standard deviation) and the change in the mean from baseline are reported by groups.

RESULTS

The follow-up daytime mean ABP was lower than the baseline daytime mean ABP in the treatment and placebo groups. In the treatment group, there was a decrease of 2.4 mm Hg in the mean systolic blood pressure and 0.9 mm Hg in the mean diastolic blood pressure. In the placebo group, a decrease of 1.4 mm Hg was observed in the mean systolic blood pressure and diastolic blood pressure (Table).

Discordant to the findings for daytime mean ABP, the nighttime follow-up mean systolic and diastolic ABP were higher than the baseline measures (Table). In the placebo group, the nighttime mean systolic blood pressure increased by 1.5 mm Hg and the mean diastolic ABP increased by 2.8 mm Hg. In the treatment group, the nighttime follow-up mean systolic ABP increased to a lesser extent. The mean nighttime systolic ABP pressure increased by 0.8 mm Hg and the nighttime mean diastolic ABP increased by 1.8 mm Hg.

The follow-up group mean 24-hour ABP was lower than the baseline mean 24-hour ABP in the treatment and the placebo groups. The differences were not statistically significant for either group.

DISCUSSION

The increased prevalence of hypertension in African Americans may be due to genetic predisposition, environmental factors, or a combination of both. The genetic hypotheses have included cardiovascular, renal and endocrine physiology, skin pigmentation and "natural selection."[1,2,14-16] The environmental theories are based on education, diet (high-fat content and inappropriate levels of sodium, potassium, and calcium intake), socioeconomic status, and racism and related stress syndrome.[15-21]

Several studies of blood pressure in African Americans support the importance of environmental influences on the expression of hypertension.[15-21] The relationship between skin pigmentation and hypertension is positive only among persons of lower socioeconomic status and educational status.[17,18,21] There is no such relation among Americans of African ancestry in higher socioeconomic and educational status.[21,20] This inconsistency may indicate that pigmentation is not a genotypic predisposition to hypertension. Increased skin pigmentation may be a phenotypic predisposition

to discrimination, leading to a lower socioeconomic status and decreased educational status. The presence of this status may increase environmental stressors that induce the neurogenic and humoral control associated with elevated blood pressure.

One article presents the hypothesis that African Americans' predisposition to hypertension may be due to "natural selection."[2] The article argues that when Africans were brought to America during the slave trade, the major cause of death was salt depletion disease due to the lack of hydration or dehydration. The Africans who survived therefore had an increased ability to conserve salt, and this obviously may be controlled genetically. This sodium retention may be associated with the increased prevalence in hypertension. It also has been suggested that sodium handling and regulation contribute to racial differences in ambulatory blood pressure patterns.[12] The African-American subjects excreted significantly less sodium than white subjects during the first 10 and 24 hours following sodium loading. The delay in sodium excretion was associated with a greater increase in blood pressure among the African Americans.

In a review on calcium supplementation of hypertensive patients,[22] 12 of the 19 studies reviewed reported a hypotensive response to calcium supplementation. A reduction of 1.8 mm Hg for systolic and 0.07 mm Hg for diastolic blood pressure has been shown in statistical analysis of pooled data from published calcium supplementation trials.[23] The present study found a 2.2 reduction in systolic blood pressure and a 0.7 mm Hg in diastolic blood pressure in the group receiving calcium supplementation. Although there was a lack of a significant association of calcium supplementation on the 24-hour mean ABP, there was a trend in this direction.

The level of blood pressure and dietary and supplemental calcium intake at baseline may affect the response to calcium supplementation.[9,22,24-26] Calcium supplementation may cause a greater lowering blood pressure on persons with hypertension and a deficiency in calcium intake.[9] The participants in the present study had a mean baseline blood pressure and calcium intake within the normal limits of the age range.

The duration of calcium supplementation also may affect the lowering of blood pressure. A critical duration for calcium supplementation has not been demonstrated.[27] In the present study, the participants were placed on calcium supplementation for 4 weeks. Eight weeks of calcium supplementation has been shown to reduce blood pressure,[24-26] and a reduction also has been seen within 4 weeks of supplementation.[27] Other studies have not detected any reduction with supplementation greater than 8 weeks.[28] Additional research is needed to determine the effects of long term calcium supplementation and the response to different levels of calcium intake and blood pressure.

The interpretation of this study is limited by the small sample size. Perhaps a larger number of participants could have detected a significant difference between the treatment group and the control group. Although these findings did not express a significant decrease in the mean ABP with calcium supplementation, a trend in this direction was found.

CONCLUSION

Hypertension is complex. More data are needed to understand the complex factors leading to the increased prevalence of hypertension in African Americans. Until additional preventive measures are found, known preventive strategies associated with physiological pathology of blood pressure must be used. These strategies include diet, exercise, stress coping education, and blood pressure examination.

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