

THE RELATIONSHIP BETWEEN CAFFEINE AND BLOOD PRESSURE IN PREADOLESCENT AFRICAN AMERICAN GIRLS

Background: While high caffeine consumption has been shown to be associated with increased blood pressure in controlled experiments, the relationship between caffeine consumption and blood pressure in preadolescent (ages 6–11 years) and adolescent (ages 12–19 years) children has not been well studied. The primary objective of this study was to assess the cross-sectional relationship between caffeine intake and blood pressure in 8- to 10-year-old African American girls who eat an unrestricted diet.

Methods: Demographic, 24-hour dietary recall, and blood pressure data collected at baseline from 303 African American girls aged 8–10 years in the Girls Health Enrichment Multisite Studies (GEMS) cohort were analyzed by using linear and multiple regression models.

Results: Dietary caffeine intake was not associated with either systolic or diastolic blood pressure ($P = .33$ and $P = .36$, respectively). However, consistent with the literature, height and body mass index were each positively and independently associated with systolic blood pressure (both $P < .0001$). Height and amount of sodium intake were positively associated with diastolic blood pressure ($P = .01$ and $P = .02$, respectively).

Conclusions: Dietary caffeine intake in low amounts is not associated with elevated blood pressure in 8- to 10-year-old African American girls who eat an unrestricted diet. (*Ethn Dis.* 2008;18:283–288)

Key Words: Caffeine, Child, Blood Pressure, African Americans, Risk Factors

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INTRODUCTION

Hypertension is one of the leading causes of cardiovascular disease (CVD) and premature mortality in the United States.¹ The prevalence of primary hypertension among adolescents (ages 12–19 years) is increasing.^{2,3} A diagnosis of hypertension established in childhood or adolescence is associated with development of left ventricular hypertrophy⁴ and atherosclerosis⁵ before the third decade of life.

Research on the pressor effect of caffeine in preadolescents is limited. While caffeine intake in higher amounts increases blood pressure acutely in short-term, experimental studies in both adults^{6–12} and children,^{13,14} the long-term effects of caffeine consumption on blood pressure are not well understood. A metaanalysis of controlled clinical trials reported a greater effect of coffee consumption on systolic blood pressure (SBP) and diastolic blood pressure (DBP) in trials involving younger participants.¹⁵ However, no linear association has been observed between caffeine consumption and incident hypertension during a 12-year period in the Nurses' Health Study.¹⁶ No natural, observational studies have assessed the linear relationship between amount of caffeine intake and blood pressure in children.

Preadolescent (ages 6–11 years) and adolescent African American children have higher SBP and DBP than their White counterparts.^{17,18} In a short-term experimental study of 159 healthy, normotensive adolescent children (mean age 16.4 years), SBPs in African American adolescents with the highest caffeine intake were greater than those of all other adolescents in the study, including White teens with the highest caffeine intake.¹⁴ The effect of regular intake of high amounts of caffeine on blood pressure in preadolescent African

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American girls, who are at risk for development of obesity, hypertension, and CVD, has not been studied.

The primary aim of the present study was to assess the cross-sectional relationship between dietary caffeine intake and blood pressure among 8- to 10-year-old African American girls who were eating an unrestricted diet. To accomplish this aim, we analyzed baseline data from the Girls Health Enrichment Multisite Studies (GEMS) cohort. Blood pressure in children and adolescents, as reported in standard blood pressure tables, is associated with sex, age, and height.¹⁹ Higher sodium intake is also associated with higher blood pressure in children and adolescents.^{20,21} Hence the relationship between blood pressure and age, height, and sodium intake was also analyzed in the present study.

DESIGN AND METHODS

Study Setting and Sample

GEMS is an ongoing research project that develops and tests interventions designed to prevent excess weight gain in 8- to 10-year-old preadolescent

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African American girls.^{22,23} Phase 1 of GEMS, consisting of formative assessment and pilot work, was conducted at four field centers located at Baylor College of Medicine, Houston; the University of Memphis, Memphis; the University of Minnesota, Minneapolis; and Stanford University, Palo Alto. A coordinating center located at the George Washington University Biostatistics Center, Washington, DC, provided support and coordination for key study activities. The National Heart, Lung, and Blood Institute sponsored the project and collaborated in its design. Phase 2 of GEMS was conducted at the University of Memphis and Stanford University and involved testing interventions developed in phase 1. Each field center's study was approved by its local institutional review board, and the present study was approved by both Mayo Foundation and University of Memphis institutional review boards. Baseline data collected on the girls who participated at the Memphis center for phase 2 were used in this report. Written informed consent was obtained from parents/caregivers, girls provided their assent, and the consent was witnessed by a GEMS staff member.

The Memphis GEMS study enrolled 303 preadolescent (aged 8–10 years), African American girls who were determined to be at risk for developing obesity. All the girls in the Memphis GEMS cohort were at least at the 25th percentile of age- and sex-specific body mass index (BMI) or had at least one overweight or obese parent/guardian, defined as BMI ≥ 25 kg/m². Data collected at baseline included demographic information such as age, height, weight, physical measures such as blood pressure, and three 24-hour dietary recalls each obtained one to two weeks apart.

ANTHROPOMETRIC MEASURES

Body weight was measured by using a calibrated scale (SECA, Model 5602

Scale, White Plains, NY), while the girl was wearing lightweight indoor clothing. Height was measured by using a stadiometer (Shorr Height Measuring Board, Olney, Md), while the girl was barefoot. Weight was measured to the nearest .1 kg and height to the nearest .1 cm. Two readings of height and weight were taken, and the mean of the two was used. BMI was calculated as body weight in kilograms divided by the square of height in meters. BMI was converted into a percentile based on the Centers for Disease Control and Prevention (CDC) age- and sex-specific 2000 growth charts and algorithms available on the CDC website for researchers.²⁴

Blood Pressure Measurement

Blood pressure was measured by using an automated blood pressure monitor (Dinamap Pro 100, Milwaukee, Wisc). Three pediatric (small, medium, large) and one standard adult cuff were available. The correct cuff size was determined by using standard criteria; the cuff bladder width was required to be $\approx 40\%$ of the circumference of the arm measured at a point midway between the olecranon tip (tip of the elbow) and the acromion (tip of the shoulder), and the cuff bladder length had to cover 80%–100% of the arm circumference.

Before putting the cuff on, the girl was instructed to rest 3–5 minutes in a seated position with both feet flat on the ground and the cubital fossa supported at heart level. The girl's elbow was placed on a table with the arm relaxed and the right sleeve was rolled up, or if it couldn't be rolled up all the way, the right arm was removed from the sleeve. All measures of blood pressure were taken only on the right arm. If the right arm was in a cast, deformed, or otherwise inaccessible, the left arm was used. Three measurements were taken, each at least one minute after the values had been computed. Mean arterial pressure, pulse pressure, SBP, and

DBP were recorded. The average of the three measurements was used for all analyses.

Dietary Measurements

At baseline, three 24-hour dietary recalls for the previous day were collected from the girls, each 1–2 weeks apart, by trained nutrition staff. Recalls covering one weekend day and one weekday were targeted. The first recall was collected in person with online interview prompts to help the subject recall the foods and with access to a food amounts booklet depicting portion sizes, to aid in estimating the amounts eaten. The other two recalls were collected by telephone with the same food amounts booklet. Parents were allowed to assist the girl's dietary recalls in an attempt to improve accuracy. These methods have been validated for use in children as young as the third grade^{25,26} and indicate the added value of parental assistance.^{22,27,28}

Information from dietary recalls was processed by using the Nutrition Data System for Research (NDS-R) software (version 4.02_30, 1999, Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minn), a software program developed at the University of Minnesota's Nutrition Coordinating Center (NCC) for collection, coding, and analysis of dietary data.^{29,30} The NDS-R 4.02 features a multiple-pass approach that prompts for complete food descriptions and preparation methods and includes >16,000 foods and values for 117 nutrients and nutrient ratios.²⁹ The GEMS investigators selected a behavior-based coding system approximating the national 5 A Day guidelines³¹ and developed coding algorithms for use with the NDS-R. A behavior-based coding system had construct validity among these 8- to 10-year-old African American girls who participated in the GEMS study.^{32,33}

GEMS staff collected the information and recorded it with a laptop computer equipped with the NDS-R.

All data collectors attended a rigorous training program and were certified in using NDS-R to collect dietary recalls. The data collectors were not involved as investigators in the study and they were blinded to the study hypotheses. According to NDS-R procedures, a multiple-pass approach was used to provide the girls with several opportunities to recall food and beverage consumption for the previous day. An initial brief listing of meals and foods was entered into the computer. This listing was followed by prompts for additional foods not previously recalled and for more detailed information regarding each food listed. Additional foods consumed were often remembered and recorded during the probing. After probing, the data collector read what was recorded and queried for verification and completeness. At each center, a lead nutritionist reviewed each recall and sent all the information to the coordinating center, where a second review was conducted. The final data cleaning procedure required verification between the coordinating center and each field center, and this data file was used in all analyses.

Measurement of Dietary Intake of Caffeine and Sodium

Amounts of caffeine and sodium intake were derived from 24-hour dietary recalls by using the NDS-R and averaged over the three recalls to estimate mean daily intake in milligrams per day. Foods and beverages that were analyzed to derive the amount of caffeine intake from the 24-hour dietary recall data included soft drinks/carbonated beverages, fruit drinks, tea, coffee, and coffee substitutes.

Data Analysis

Average of the recalls was used to represent amounts of caffeine and sodium intake per day. The relationship between blood pressure and age, height, BMI, and average daily amounts of caffeine and sodium intake was tested

Table 1. Demographic and dietary characteristics of 303 preadolescent African American girls enrolled in the Girls health Enrichment Multisite Studies, Memphis, Tennessee

Characteristic	Mean ± Standard Deviation or n (%)
Age (years)	9.3±.87
Body Mass Index (BMI) (kg/m ²)	21.8±5.8
At-risk of overweight (BMI-for-age 85th to <95th percentile), n (%)	50 (16.5)
Overweight (BMI-for-age ≥95th percentile), n (%)	123 (4.6)
Systolic blood pressure (mm Hg)	10.0±11.0
Diastolic blood pressure (mm Hg)	56.3±6.5
Average daily caffeine intake (mg/day)	11.0±14.4
Average daily sodium intake (mg/day)	2499.0±925.0
Average daily caloric intake (kcal/day)	1497.0±471.5

by using univariate and multivariate regression models. Blood pressure was the outcome variable for these models. The primary predictor variable was amount of caffeine intake, which was adjusted for age, height, BMI, and sodium intake. To achieve the most parsimonious model, each of the potential covariates was added to the model one at a time in a forward stepwise fashion until the greatest number with statistical significance (*P* <.05) were included.

Interaction between the primary predictor and sodium intake was also tested. The interaction term was not significant; therefore, it was not included in the final multiple regression models. The final model in each section was assessed for the assumptions of linear and multiple regressions, as applicable, by using residual plots. Exploratory analyses were conducted that treated caffeine intake as a categorical variable by stratifying caffeine intake data into quartiles; we also examined sources of caffeine as predictor variables.

RESULTS

Demographic, anthropometric, and dietary characteristics of the 303 girls who participated in this study are summarized in Table 1. Two participants completed one dietary recall, 16

completed two, and 285 completed all three. Data from all the girls who participated in this study were included in the analyses. Fifty-seven percent of girls were either at risk of overweight (BMI-for-age 85th percentile to <95th percentile) or overweight (BMI-for-age ≥95th percentile), and 86% of girls had a mother/caregiver who was either overweight (BMI 25.0–29.9 kg/m²) or obese (BMI ≥30.0 kg/m²). Mean amount of caffeine intake was 11.0 mg/day (standard deviation 14.4 mg/day). The major source of caffeine was carbonated beverages. Further details on caffeine intake of the cohort are provided in Table 2.

Neither caffeine nor dietary sodium intake was significantly associated with SBP (Table 3). Age, height, and BMI

Table 2. Distribution of average daily caffeine intake of preadolescent African American girls enrolled in the Girls health Enrichment Multisite Studies, Memphis, Tennessee

Average daily caffeine intake (mg/day)	No. participants
0	34
>0 and ≤10	159
>10 and ≤20	55
>20 and ≤30	25
>30 and ≤40	15
>40 and ≤50	9
>50 and ≤100	5
>100	1

Table 3. Univariate and multivariate analyses of the association between systolic blood pressure and demographic and dietary characteristics in a cohort of 303 preadolescent African American girls enrolled in the Girls health Enrichment Multisite Studies, Memphis, Tennessee

Variable	Univariate Analysis		Multivariate Analysis	
	Estimate*	P value	Estimate*	P value
Caffeine intake (mg)	.43	.33		
Age (years)	2.52	.0004	-.26	.74
Height (cm)	4.57	<.0001	3.18	.0002
Body mass index (kg/m ²)	.78	<.0001	.57	<.0001
Sodium intake (mg)	-.001	.84		

* Univariate and multivariate estimates reflect the overall and adjusted difference in systolic blood pressure associated with either a 1-unit change in age and body mass index or a 10-unit change in caffeine, height, or sodium intake.

had a significant positive association with SBP in the univariate model, but in the multivariate model, only height and BMI were positively associated with SBP. As expected in this age group, a significant correlation between age and height was observed, and the association between age and SBP was confounded by height. The final multiple-regression model with age, height, and BMI as the predictor variables and SBP as the outcome variable indicated that in these 8- to 10-year-old African American girls, there would be a .6 mm Hg difference in SBP between two girls of the same age and height who had a difference in BMI of 1 kg/m². BMI alone accounted for 16.6% of the variance in SBP, and in the multiple regression model, BMI, height and age together accounted for 21.8% of the variation in SBP.

Height and amount of sodium intake were observed to have a significant positive association with DBP in both the univariate and multivariate models, and no significant interaction was observed between height and sodium intake (Table 4). A difference in sodium intake of 1000 mg/day between two girls in the study who were of similar age and height was associated with a difference in DBP of 1 mm Hg.

Categorizing average daily caffeine intake into quartiles did not show any significant difference in blood pressure between the four groups. We observed

no significant difference in blood pressure between girls who had any amount of caffeine intake versus those who had none. Source of caffeine also was not associated with blood pressure.

DISCUSSION

Caffeine intake at low doses was not associated with either SBP or DBP in our cohort of 8- to 10-year-old African American girls who ate an unrestricted diet. Height was positively associated with both SBP and DBP. BMI was positively associated with SBP, and sodium intake was positively associated with DBP.

Our study is the first purely observational study to look at the relationship between caffeine and blood pressure in preadolescent children from an at-risk

population, without any interventions, who are eating unrestricted diet. The observations on the association between blood pressure and age, height, BMI, and sodium intake are consistent with data in standard blood pressure tables¹⁹ and other existing literature,^{18,20,34-40} which indicates that our results are valid. The relatively smaller change in DBP as compared with SBP associated with a difference in height is also consistent with data in standard blood pressure tables. Although our study was limited to African American girls, previous reports have demonstrated a similar association of BMI with blood pressure among boys³⁷ and in children of other races.³⁴⁻⁴⁰ The positive association between sodium intake and DBP has also been reported in the past.^{41,42} Validated measures of dietary recall were used, and standardized methods to measure blood pressure and weight were instituted. Our approach attempted to ensure internal validity of the results.

The hypothesized dose-response relationship between caffeine intake and blood pressure was not confirmed, but this finding is difficult to interpret in light of a lack of previous reports. The absence of a significant association could have been affected by the small sample size, limited variability in the average amount of caffeine intake among participants, relatively low amounts of caffeine intake overall, or perhaps inaccurate measurement of

Table 4. Univariate and multivariate analyses of the association between diastolic blood pressure and various demographic and dietary characteristics in a cohort of 303 preadolescent African American girls

Variable	Univariate Analysis		Multivariate Analysis	
	Estimate*	P value	Estimate*	P value
Caffeine intake (mg)	.24	.36		
Age (years)	.48	.26		
Height (cm)	.94	.02	1.02	.01
Body mass index (kg/m ²)	.12	.07		
Sodium intake (mg)	.01	.01	.01	.01

* Univariate and multivariate estimates reflect the overall and adjusted difference in diastolic blood pressure associated with either a 1-unit change in age or body mass index or a 10-unit change in caffeine intake, height, or sodium intake.

caffeine intake extracted from dietary recalls. However, the expected relationship between sodium intake and blood pressure was observed with the same methods. Previous studies in both adults and children have shown a significant association of caffeine with blood pressure elevation acutely when the amount of caffeine intake was >50 mg/day or >100 mg/day.^{8,13,14,43-45} Only six subjects in our study had an average amount of caffeine consumption >50 mg/day, and only one subject had an average intake >100 mg/day. In this sample of African American girls, social desirability was identified to bias self-reports of diet and physical activity, and underreporting of caffeine intake appears likely.

Several limitations of our study exist. First, the study is limited by the blood pressure measurement method used, which should have been conducted over three consecutive days; all three blood pressure recordings on the girls in the current study were taken on one day. Second, this is a cross-sectional analysis of the baseline data of a longitudinal study, and only a correlation between various predictors and blood pressure can be suggested. Third, although rigorous quality control was applied, a potential for recall bias for dietary intake exists because the information on 24-hour dietary intake for the previous day was based on memory and recall. The dietary recall method used, which highlights carbonated bev-

erages as the primary, but low-dose, source of caffeine is a limitation with regard to possible underestimation of caffeine intake.

This study enhances our understanding of the relationship between caffeine intake, sodium intake, and blood pressure in 8- to 10-year-old preadolescent African American girls. Consistent with epidemiologic and long term clinical trial results in adults, dietary caffeine intake at low doses does not appear to have an association with either SBP or DBP in 8- to 10-year-old African American girls who eat an unrestricted diet. Further research focused on delineating the role of caffeinated soft drinks and other dietary factors that have been shown to have an impact on blood pressure in older age groups appears warranted in this high-risk population.

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