Genetic Determinants of Blood Pressure Level Among the Black Caribs of St. Vincent[1]

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ABSTRACT

The Black Caribs of St. Vincent Island are a mixture of African, Arawak, and Carib (Venezuela) ancestry. The biological consequences of this tri-ethnic admixture in relation to blood pressure level was investigated in a sample of 421 Black Caribs from three villages, however, no statistically significant relationship was observed between African ancestry and blood pressure. Estimation of the heritability of blood pressure was determined utilizing familial data. Correlations between mother-offspring diastolic pressure and sib-sib systolic and diastolic pressures were significant at the 0.05 level. Mean blood pressure within various age cohorts were compared to Black American, Carawak, and African populations. The Black Caribs of St. Vincent Island appear to be more similar to Black Americans regarding changes in blood pressure level with age.

The etiology of essential hypertension is unknown; however, an assortment of both environmental and genetic factors contribute to high blood pressure (Hamilton et al. 1954; Langford et al. 1968; Weinberg et al. 1979). When considering the environmental factors, Guyton (1974) suggested that hypertensives excrete salt less easily than normotensive individuals. A number of socio-cultural variables have also been posited as causal elements in blood pressure elevation. For instance, marital status, number of children, and church attendance may contribute to high blood pressure (Scotch, 1963). Although both environmental and genetic factors may elevate blood pressure the relative magnitude of each is unknown and both contributions may vary depending upon the evolutionary circumstances of the population in question.

The type of distribution observed for quantitative traits may provide some indication as to the mode of its inheritance. A bi- or tri-modal distribution is expected if a single pair of genes regulate blood pressure. To date no such distribution for blood pressure has been demonstrated in populations examined. Rather, a unimodal distribution is observed, thus suggestive of a polygenic mode of inheritance (Hamilton et al. 1954; Dahl,

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1963; Miall, 1977). The nature of the hereditary component of blood pressure may be ascertained by examining the phenotypic similarity between relatives. Twin analysis, pedigree studies, family aggregation, and hybrid studies have been utilized in this manner to study the genetics of blood pressure (MacLean et al. 1974; Tyroler, 1977; Lee, 1978; Havlik et al. 1979; Rose et al. 1979). Hybrid analysis presents a unique opportunity for analyzing the biological consequences of admixture.

The Black Caribs on St. Vincent Island are a complex amalgamation of Indian and West African parental populations. It has been estimated that in approximately 100 A.D. Arawak Indians settled on St. Vincent (Haag, 1965). Then, in the 1300's, Carib Indians during their expansion from Venezuela also moved to the island (Taylor, 1951; Haag, 1965). This is demonstrated by the pottery-style sequences excavated in sites on the Island of St. Vincent. The Arawak manufactured plain coiled ware whereas the Caribs produced Lavoutte Plain pottery made from a gritty paste (Haag, 1965). The archeological evidence supports the formation of a bi-ethnic Indian population. A number of historical events created opportunities for this Amerindian hybrid group to intermix with West Africans. There is documentation that Africans were shipwrecked on the island and that slaves from surrounding islands sought refuge on St. Vincent (Taylor, 1951). The bi-hybrid African-Indian group formed from this intermixture retained the culture of the Carib Indians and their descendants are the present-day Black Caribs of St. Vincent (Gullick, 1976).

It is estimated that in the 1600's the Black Caribs numbered approximately 3000 individuals. The population subsequently has undergone a series of numerical bottlenecks (Gullick, n.d.). Gullick (1976) estimated that 2500 Black Caribs were deported to Roatan in 1797, leaving a few hundred Caribs on St. Vincent. The remaining population experienced wars, hurricanes, and a series of volcanic eruptions. The exact size of the present Black Carib population is not known because of the ambiguity associated with the definition of ethnicity (Gullick, n.d.; 1976).

Materials and Methods

Figure 1 provides the locations of the villages sampled in these preliminary investigations. After the 1902 volcanic eruptions, Black Caribs resettled in these communities and established a new community, Rose Bank. Caribs live on both the windward and leeward sides of the island but only a single Carib settlement exists in the interior (Gullick, 1976).

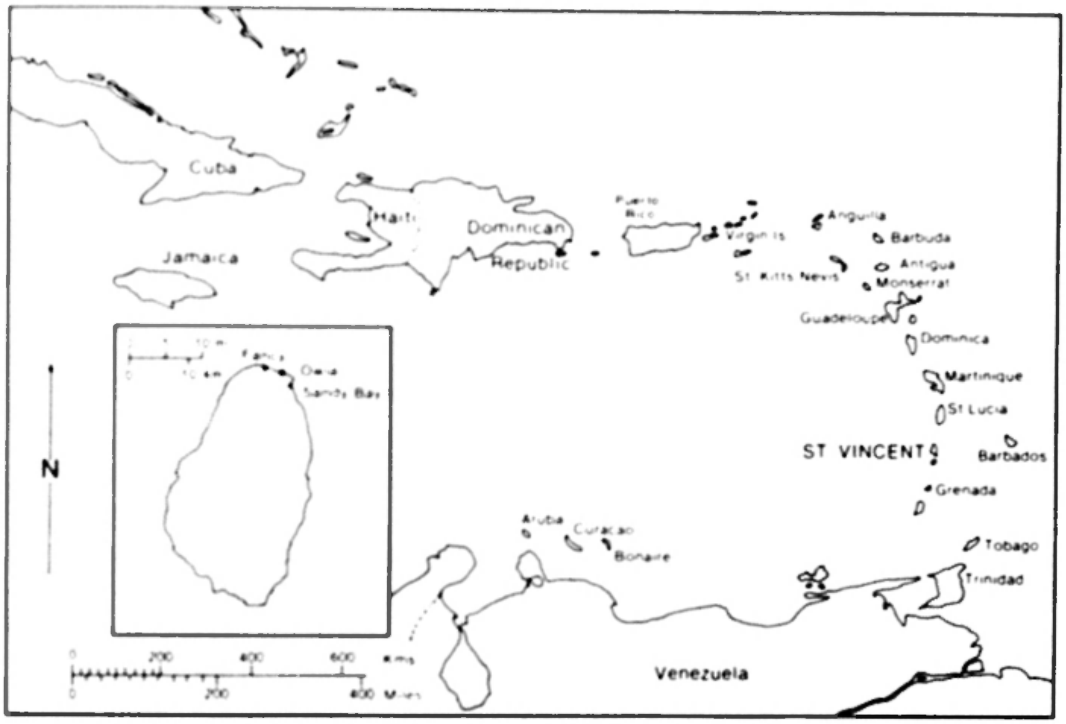

FIG. 1. Geographical location of St. Vincent in the Lesser Antilles.

Blood pressures were taken on 193 individuals from Sandy Bay, 132 individuals from Owia, and 96 from Fancy (see Table 1). Their age ranged from 10 to 90 years, however, the sample sizes for the young and aged groups are relatively small. Subjects were seated for approximately five minutes prior to blood pressure determination and were informed as to the nature of the study and the measurement techniques. A single blood pressure reading was taken while each individual was in a seated position with the left arm resting on a table. A baumanometer with a 14 centimeter wide compression cuff was then positioned at heart level and systolic and diastolic, phase V, pressures were measured. Individuals were also screened for possible renal malfunctions through urine analysis since such abnormalities may produce secondary hypertension.

Familial systolic and diastolic product moment correlations were computed. Correlation coefficients are given for 68 mother-offspring pairs, 32 father-offspring pairs, and 70 sibships. These coefficients were calculated after adjustment for age and sex by regression analysis. Heritability estimates were computed utilizing mother-offspring and father-offspring regression coefficients. Husband-wife blood pressure correlations were not measured because of small sample size, therefore the

Table 1

Numerical and Sex Distribution of the Population Sample from St. Vincent Island, Collected during the Summer of 1979

Village	Males	Females	Total
Sandy Bay	71	122	193
Owia	46	86	132
Fancy	36	60	96
Total	153	268	421

presence of assortative mating was not estimated. However, regression analysis is unaffected by nonrandom mating since the covariance is reduced to the same level as the variance among parents so that the slope of the regression line is not significantly altered by assortative mating (Falconer, 1960). Therefore regression of offspring on parents provides a valid estimate of heritability, while computing standard errors for these estimates.

Socially, sibs are more similar to each other than they are to their parents. In terms of occupation, the type of jobs performed are more similar among sibships than between parents and offspring. Hence, since sibships share a common environment which would inflate the genetic component, sib-sib heritability estimates are not computed. While at this phase of the investigation, the environmental differences between generations cannot be measured with precision, future research will focus upon this question.

Blood specimens were drawn from 373 individuals and analyzed by the Minneapolis Blood Bank for the following systems: ABO, MNSs, and Rhesus. Only the co-dominant alleles C,c and E,e of the Rhesus system were included in the analysis. Gene frequencies from Sierra Leone, Nigeria, Senegal, Liberia, and the Ivory Coast were averaged to form a composite West African population (Mourant et al. 1976). Arawak and Carib gene frequencies based upon Geerdink et al. 1974, were also averaged to estimate the parental gene frequencies for the Amerindian ancestral group which will be referred to as "Carawak" in this manuscript. Together, these populations constitute the parental ancestry for the Black Caribs of St. Vincent.

Admixture was estimated using a program written by R. C. Elston

(1968), which includes two measures of admixture: Roberts and Hiorns and "true least squares" (Roberts and Hiorns, 1962, 1965; Elston, 1971). Both estimates assume drift and selection are absent and that the allelic frequencies of the parental population are represented adequately by the composite groups from West Africa and South America (Crawford et al. 1976). From the known gene frequencies of combined loci the amount of admixture contributed by parental populations to the hybrid groups was computed. The basic equation is $Q_n = M^n Q_o$, where Q_n is the matrix of gene frequencies for the hybrid populations, and M^n is the amount of admixture after n generations (Roberts and Hiorns, 1962). These estimates can range from 0 to 100% West African contribution to the gene pool. Individual estimates of M were calculated by treating each person as an independent hybrid gene pool.

Admixture estimates for each individual were computed in this manner and were associated with their corresponding blood pressure level using chi-square analysis. In this study, admixture estimates were partitioned into four quartile cohorts and blood pressures were divided into two groups, normotensives and hypertensives. Hypertension was defined as a diastolic reading at or above 95 mm high while recordings below this level were considered normotensive. This "conservative" definition of hypertension follows the proscription of the 1959 conference on Methodology in Epidemiological Studies in Cardiovascular Disease held in Princeton, New Jersey (Lee, 1978). The relationship between varying degrees of admixture and blood pressure level was then tested.

Results

Figure 2A shows the distribution of blood pressure by sex and age for both systolic and diastolic pressures. For systolic pressure, males exceed females until about 35–45 years of age, then female systolic pressure accelerates. This spurt lasts until the individuals are about 50-55 years old, at which time a continued increase is noted, but to a lesser degree. At about age 70, male systolic pressure surpasses that of females. Diastolic pressure presents a similar pattern, with males exceeding females until about the age of 40–45 years, when female blood pressure surpasses male pressure. At about 60 years of age the diastolic pressures of both males and females show a diminution. However, both sexes show an increase at about age 70 years old. The overall pattern indicates that blood pressure is age dependent.

Blood pressures for the Black Caribs of St. Vincent are compared to arterial pressures for the Carajas of Brazil (Lowenstein, 1961), the Ilora tribe in Western Nigeria (Abraham et al. 1960) and Black Americans in Muscogee County, Georgia (Comstock, 1957) in Figure 2. The Carajas exhibit no increase in blood pressure with age for diastolic pressure and only a slight increase for systolic pressure. The Ilora present a similar pattern with only female systolic pressure showing a marked increase between the ages of 35 and 55 years old. It should be noted that although the two groups present similar patterns, mean blood pressure for each age group is higher in the West African sample than the Brazilian group.

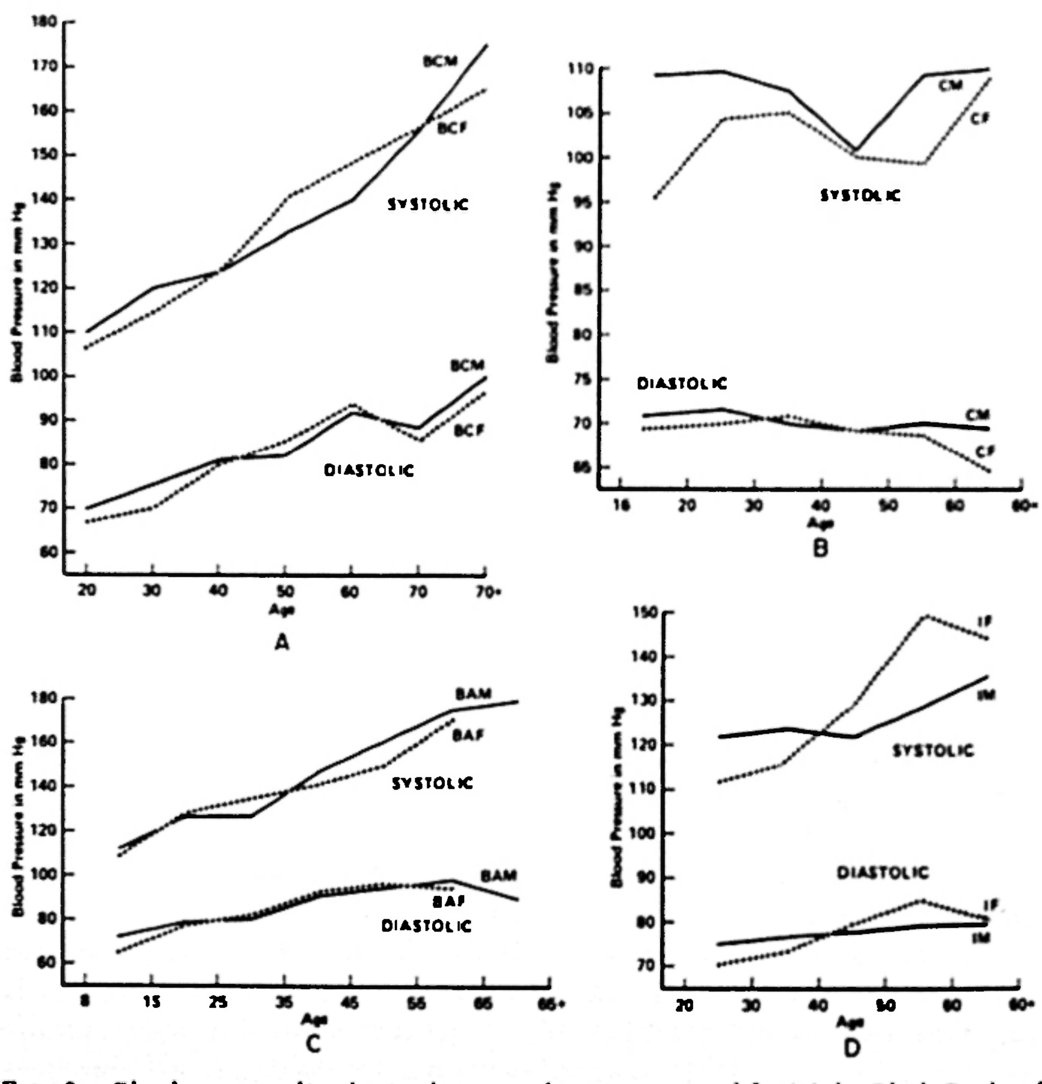

FIG. 2. Blood pressure distribution by age and sex is compared for (A) the Black Caribs of St. Vincent, BC, (B) the Carajas of Brazil, C, (C) Black Americans from Muscogee County, Georgia, BA, and (D) the Ilora of Western Nigeria, I.

When both groups are compared to St. Vincent only the Black Caribs present noticeable increments in blood pressure with age. On the other hand, when the Black Caribs are compared to Black Americans a striking similarity is revealed. Both samples present comparable mean blood pressure by age cohort, and both show increments in blood pressure with age.

The West African and Carawak samples represent the ancestral populations for the Black Caribs on St. Vincent. When gene frequencies are compared (Table 2) the Black Caribs are always intermediate (except for the NS and MS frequencies). However, the gene frequencies for the Black Caribs are more similar to West Africans than Carawaks for almost every locus. Also, the gene frequencies for Black Caribs, West Africans and Black Americans (from Miami, Florida and New York, Mourant et al., 1976) are very similar. This pattern is also demonstrated for arterial pressure with these groups presenting higher mean values for each age group than is found among the Brazilian group. Black Americans and Black Caribs show similar gene frequencies and blood pressure level distributions. Because of these similarities the African contribution will be stressed in the present study.

Table 2

Gene Frequency Distribution for the Black Caribs of St. Vincent, Black Americans, Carib-Arawaks, and West Africans

	Carawak	St. Vincent	West African	Black Americans
ABO:				
A	0.0075	0.1574	0.2724	0.2620
B	0.0000	0.0978	0.2408	0.2520
O	0.9925	0.7448	0.4868	0.4860
Rhesus:				
Ce	0.5685	0.0736	0.0683	0.0881
cE	0.2970	0.2548	0.0787	0.1441
ce	0.0437	0.4441	0.5733	0.3383
CE	0.0235	0.0041	0.0000	0.0000
Ce	0.5685	0.0396	0.0056	0.0449
ce	0.0438	0.1838	0.2525	0.3846
MNSs:				
MS	0.1590	0.0533	0.0948	0.0885
Ms	0.4235	0.4003	0.3494	0.4015
NS	0.0820	0.0951	0.0429	0.0718
Ns	0.3355	0.4513	0.5129	0.4382

Table 3 provides a summary of the familial product moment correlations and heritability estimates for the Black Carib samples from St. Vincent. Diastolic pressures are consistently the highest and only father-offspring correlations are nonsignificant, possibly the result of small sample size, maternal effects, or ascertainment problems. Since only 32 father-offspring pairs were utilized, sample size is the most likely factor responsible for the low correlations. Mother-offspring diastolic correlation is significant while the systolic correlation is almost significant. Both systolic and diastolic correlations are significant for the sibships.

The correlation coefficients presented in this study were compared to other published reports and found to fall within the range of correlations of previous studies. For systolic pressure, parent-offspring correlation coefficients ranged between 0.13 and 0.34; and for diastolic pressure the corresponding range was 0.08–0.38 (Tyroler, 1977). The highest values are for families with two or more children between the ages of 1-21, while no clear trend was apparent for the lower values. Sibships ranged between 0.14–0.55 for systolic pressure and between 0.12–0.58 for diastolic pressure. The highest correlations observed are between monozygotic twins. Dizygotic twins appear to resemble regular sibships with a correlation coefficient of 0.25 and 0.27 for systolic and diastolic pressures, respectively.

When similarity between relatives are compared to families with adoptive children, the importance of heredity is illuminated. Biron et al.

Table 3

Familial Aggregation of Black Carib Blood Pressure

Relationship		h^2	
SBP	Correlation	Regression	S.E.
Mother-offspring	0.22	0.296	0.162
Father-offspring	0.13	0.134	0.184
Sibship	0.24*		
DBP			
Mother-offspring	0.30*	0.434	0.168
Father-offspring	0.14	0.138	0.180
Sibship	0.27*		

*$p < 0.05$.

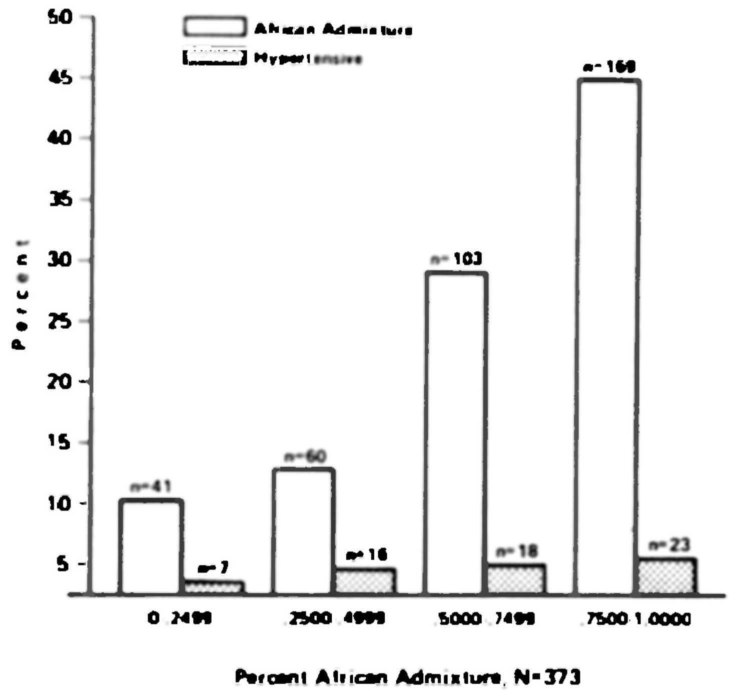

FIG. 3. Frequency of hypertension and African admixture.

(1976) investigated familial aggregation of blood pressure in 558 adopted children. These children demonstrated no significant aggregation either with their adoptive parents or with their adoptive brothers and sisters. Analyses of familial versus adoptive relationships clearly demonstrate the significance of inheritance in determining arterial pressure.

Since both Black Caribs and Black Americans possess similar gene frequencies and blood pressure distributions, it was suggested that this similarity is related to their West African ancestry. Therefore the relationship between blood pressure level and African admixture was selected for separate analysis among the Black Caribs. Figure 3 compares the degree of individual African admixture to the frequency of hypertensives and demonstrates no significant increase in hypertension as African admixture increases. Of 373 individuals, it is estimated that 73% of the population received one-half or more of their genes from an African ancestor and of these individuals, 15% are hypertensive. Seventeen percent of the total sample, who attended the health clinic, exhibited clinical symptoms of hypertension. Table 4 presents the distribution of normotensive and hypertensive individuals within quartiles of varying admixture. A chi-square test was used to examine the dependence of blood pressure on percentage African ancestry. Such an investigation cannot demonstrate a

Table 4

*The Distribution of African Admixture Among Normotensive and Hypertensive Cohorts**

% African Admixture	Normotensive	Hypertensive
0.00-0.24	34	7
0.25-0.49	44	16
0.50-0.74	85	18
0.75-1.00	146	23

*Chi square = 5.32 with 3 degrees of freedom.

causal relationship or present information relating to the biological processes involved in this association, however, it can provide the probability of observing such a relationship by chance. The chi-square value for the Black Carib data is 5.32 with 3 degrees of freedom, which is not significant at the 0.05 level.

A one-way analysis of variance was used to assess the age comparability of the four quartile admixture groups. This test included both hypertensive and normotensive individuals but was not significant at either the 0.05 or 0.01 level. Hence, the admixture groups possess similar age distributions and are comparable.

Also, since a slight increase in the number of hypertensives was demonstrated as African admixture increased, a chi-square test was used to ascertain the age composition of this group. Table 5 presents chi-squares among hypertensive values for each quartile African admixture. Age groups 20-29, 30-39 and 40-49 were pooled because of small sample size. The chi-square value for each cohort is not significant at the 0.05 level demonstrating a similar distribution for each age cohort in each admixture group.

Discussion

A heritable component for blood pressure was demonstrated in the present study and in investigations in other populations. The magnitude of this contribution appears to vary depending upon the type of familial relationship examined. For instance, Miall et al. (1962) in Jamaica and

Johnson et al. (1965) in Tecumseh, Michigan found higher sib-sib correlations than parent-offspring correlations, and suggest the involvement of a strong component for blood pressure in sibs. However, both sibships and parents live in the same household creating an environmental component which may inflate similarities in blood pressure. The extent of this environmental component in one or both relationships could alter the previously mentioned situation. For example, studies in Montreal and New Zealand demonstrate higher parent-offspring than sibship correlations, although this may not be the result of an increased environmental component (Tyroler, 1977). These conflicting results demonstrate that the magnitude of the blood pressure component for a particular relationship can vary.

When considering mother-offspring diastolic pressure versus sibship diastolic pressure among the Black Caribs, higher correlations are found among the former group. This suggests a considerable environmental effect upon the blood pressure of the Black Caribs of this island. Such conflicting results illustrate the difficulty of estimating the genetic contribution involved in blood pressure in different human populations. The Montreal, New Zealand, and Black Carib studies are also "... not consistent with a simplistic hypothesis of commonly shared environments, that is, one which would predict a strong similarity among age-contemporaneous sib pairs and lower correlations in parent-offspring pairs..." (Tyroler, 1977, p. 617).

Several studies have attempted to establish a relationship between

Table 5

Numerical Distribution of Hypertensives by Age Group within African Admixture Cohorts

	Degree of African Admixture			
Age	0-0.24	0.25-0.49	0.50-0.74	0.75-1.0
20-49	1	4	5	4
50-59	3	7	5	10
60-69	2	3	5	4
70-89	1	2	3	5
χ^2	1.5714*	3.5*	.6665*	4.3043*

*Chi square = 7.815 with 3 degrees of freedom.

African ancestry and increased risk of hypertension. For example, Boyle (1970) found a tendency for darker-skinned Blacks to have higher blood pressures than lighter-skinned Blacks. MacLean et al. (1974) also used differences in the proportion of African ancestry to infer the racial component of blood pressure. They found a statistically significant relationship between diastolic pressure and African admixture. It was stated that this relationship was due to the African component, " . . . but confounding of admixture with environmental factors cannot be excluded" (MacLean et al. 1974, p. 624). However, among the Black Caribs of St. Vincent a relationship between degree of African admixture and blood pressure level could not be demonstrated. It is possible that with larger sample sizes and with improved measures of admixture this apparent relationship between African ancestry and increased risk of hypertension may be supported.

Although a heritable component for blood pressure has been demonstrated, other factors also play a role. McGarvey and Baker (1979) stated that blood pressures among Polynesian groups increased when they adopted modern or western ways. Their American Samoan sample showed an increase in blood pressure association with acculturation. If populations from the larger towns of Kingstown and Georgetown on St. Vincent are contrasted with fishermen living in villages, the effects of modernization on the Black Caribs can be ascertained. Although migration has also been posited as a cause of elevated pressure, immigration is usually from a rural to an urban area, with the new modern surroundings and not the actual migration increasing blood pressure. Smith and Sing (1976) stated that abnormal blood pressure results from maladaptiveness to the new environment or new roles or statuses required of immigrants. The inability to adapt may produce stressful situations which generate permanently elevated pressures (Smith and Sing, 1976).

Anthropometrics have also been posited as a causal factor in elevated arterial pressure. Preliminary findings on the Black Caribs demonstrate the importance of overall obesity among females and torso dimensions among males in determining blood pressure level. The relationship between body build and blood pressure will be examined in greater detail in a later paper. Similar findings are reported by Hanna and Baker (1979) among Samoans, where fatness and trunk size strongly influence blood pressure in men while in Samoan females trunk size is important. Barnicot et al. (1972) found that anthropometrics accounted for between 11 and 13% of arterial blood pressure variation. Similar findings were demonstrated in the Black Caribs of St. Vincent where heredity accounts for approximately 22% of the variation, while anthropometrics contribute another 12% to blood pressure variation.

A number of other factors such as physique, cigarette smoking, trace elements and stress also influence blood pressure. These and other factors will be further investigated using the family set method.

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