

BLOOD PRESSURE IN BLACKS AND WHITES AND ITS RELATIONSHIP TO DIETARY SODIUM AND POTASSIUM INTAKE

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(Received in revised form 30 January 1984)

Abstract—The 24-hour dietary intake and blood pressure of 1928 black and 9739 white adults derived from the data sets of the first US National Health and Nutrition Examination Survey (NHANES I) of 1971–1974 were analyzed. Contrary to expectation, the absolute and relative intakes of sodium and potassium in blacks were less than those of whites. However, because the difference in potassium was greater than the difference in sodium, blacks did have a significantly higher sodium/potassium ratio than whites. Blacks had significantly higher blood pressure than whites even when adjusted for differences in sodium/potassium ratio. It is concluded that the higher blood pressure and prevalence of hypertension in blacks does not appear to be a function of an absolutely greater dietary sodium intake, but related to a relatively low intake of potassium. It is possible that blacks have a greater sensitivity than whites to the hypertensinogenic effects of sodium which, coupled with the relatively low dietary intake of potassium, accounts for their increased blood pressure.

INTRODUCTION

THERE is a great deal of evidence indicating that blacks have higher blood pressure and a higher prevalence of hypertension than whites. At present the extent to which these differences are due to differences in genetic susceptibility or environmental factors such as differences in dietary intakes of sodium and potassium is not well defined. Some studies have shown that blacks either ingest diets containing greater amounts of sodium or excrete more sodium than whites [1–5], while others have not found differences in sodium intake [6–9]. Similarly, studies on plasma renin activity indicate that blacks ingest less dietary potassium than whites [6], but this finding has not yet been confirmed by other studies. In search of possible explanations for the greater prevalence of hypertension among blacks than whites, we have analyzed the 24-hr dietary intakes collected during the first National Health and Nutrition Examination Survey (NHANES I) of 1971–1974 in the United States. Furthermore, we have evaluated the relationship of both dietary sodium and potassium to blood pressure in both blacks and whites.

MATERIALS AND METHODS

Sample and measurements

This study is based on a cross-sectional sample of whites and blacks derived from the data sets of the first National Health and Nutrition Examination Survey of 1971–1974. This survey was concluded by the National Center for Health Statistics according to a multistage, stratified probability sample which included the selection of 28,043 persons that

represented the 194 million noninstitutionalized civilians, aged 1–74 yr, of the United States. Of the 28,043 individuals who comprised the sample population for NHANES I, 20,749 (74%) were examined. At the time of the examination when anthropometric measurements were obtained, 16,459 individuals were aged 18–74 yr. From this sample we selected a total of 11,667 blacks and whites ranging in age from 20 to 74 yr, who were not on any special diet or medication for hypertension.

This study is based on measurements of height, weight, skinfold thickness [10], blood pressure [11], and 24-hr dietary intake (12). The general protocol for the data collection is given in these publications.

Analyses

The analytical procedure was as follows. First, base 10 logarithms were taken of all the independent variables so as to correct for non-normal distributions. Second, the sample was divided into age, race, and sex groups. The age groups were: 20–24, 25–34, 35–44, 45–54, 55–64 and 65–74 years old. Age, sex, and race categorization was performed for each univariate model. The independent variables that were found to be significantly different among the blacks and whites were included as the covariate variables when comparing the blood pressures. All comparisons and evaluations of the significance of the difference in blood pressures between blacks and whites were based upon analyses of variance and covariance. The analyses of variance permitted the determination of variables that were significantly different between blacks and whites, while the analyses of covariance enabled comparisons of mean blood pressures of blacks and whites at an equal or adjusted value of the independent variable (such as calorie intake and body size). In this manner, the comparisons of mean blood pressures were corrected for the effects of the independent variables.

RESULTS

As shown in Table 1 in all age groups, except among the 25–34-yr-old males and the 20–24-yr-old females, the dietary intake of sodium and potassium is lower in blacks than in whites. These population differences remain even when the sodium and potassium intakes per 1000 calories are compared. On the other hand, the sodium/potassium ratios

TABLE 1. COMPARISON OF SODIUM AND POTASSIUM INTAKE OF BLACKS AND WHITES DERIVED FROM THE DATA SETS OF NHANES I OF 1971–1975

Age (Yr)	Race	N	log Na intake		log K intake		log calorie intake		log (Na/K)		log (Na/1000 cal)		log (K/1000 cal)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Males</i>														
20–24	W	421	3.44**	0.26	3.46**	0.23	3.44**	0.18	–0.015*	0.25	3.00*	0.21	3.01**	0.16
	B	80	3.30	0.31	3.23	0.29	3.35	0.22	0.065	0.24	2.95	0.20	2.88	0.19
25–34	W	664	3.40	0.26	3.44**	0.21	3.40	0.17	–0.036*	0.25	3.00	0.22	3.03**	0.16
	B	113	3.35	0.27	3.32	0.24	3.38	0.18	0.028	0.27	2.97	0.23	2.95	0.16
35–44	W	554	3.41**	0.25	3.43**	0.20	3.38*	0.17	–0.018	0.22	3.03	0.21	3.05**	0.14
	B	79	3.31	0.33	3.28	0.26	3.33	0.23	0.030	0.35	2.99	0.26	2.95	0.21
45–54	W	636	3.36**	0.25	3.39**	0.19	3.34**	0.17	–0.025**	0.23	3.03	0.21	3.05**	0.15
	B	116	3.27	0.26	3.15	0.31	3.25	0.22	0.117	0.28	3.02	0.19	2.91	0.20
55–64	W	431	3.34**	0.28	3.36**	0.20	3.29**	0.18	–0.025	0.26	3.05*	0.21	3.07**	0.15
	B	69	3.20	0.25	3.20	0.30	3.22	0.20	0.002	0.26	2.98	0.20	2.98	0.22
65–74	W	1098	3.29**	0.24	3.32**	0.20	3.23**	0.17	–0.023**	0.23	3.06**	0.19	3.09**	0.15
	B	221	3.14	0.32	3.11	0.30	3.15	0.19	0.028	0.27	2.99	0.25	2.96	0.23
<i>Females</i>														
20–24	W	950	3.21	0.29	3.23**	0.25	3.18	0.19	–0.020**	0.28	3.02*	0.22	3.04**	0.18
	B	255	3.17	0.33	3.13	0.27	3.19	0.19	0.040	0.31	2.99	0.26	2.95	0.21
25–34	W	1522	3.20**	0.29	3.25**	0.24	3.17*	0.20	–0.050**	0.26	3.03**	0.21	3.07**	0.17
	B	315	3.10	0.34	3.09	0.34	3.15	0.22	0.009	0.31	2.95	0.25	2.94	0.26
35–44	W	1240	3.20**	0.26	3.25**	0.21	3.17**	0.18	–0.057**	0.24	3.03**	0.20	3.09**	0.17
	B	283	3.07	0.30	3.07	0.26	3.10	0.20	–0.003	0.30	2.97	0.23	2.97	0.21
45–54	W	742	3.18**	0.27	3.25**	0.21	3.15**	0.19	–0.067	0.26	3.04**	0.21	3.10**	0.16
	B	130	3.04	0.34	3.07	0.27	3.08	0.19	–0.032	0.32	2.95	0.27	2.98	0.21
55–64	W	439	3.15**	0.28	3.24**	0.20	3.12**	0.16	–0.098	0.27	3.03*	0.22	3.13**	0.16
	B	74	3.03	0.24	3.10	0.26	3.05	0.20	–0.074	0.26	2.97	0.22	3.05	0.18
65–74	W	1039	3.13**	0.25	3.22**	0.20	3.09**	0.17	–0.092	0.25	3.04**	0.20	3.13**	0.16
	B	193	3.01	0.36	3.07	0.28	3.02	0.21	–0.057	0.34	2.99	0.30	3.05	0.20

* $p < 0.05$, ** $p < 0.005$.

TABLE 2. COMPARISON OF ANTHROPOMETRIC CHARACTERISTICS AND BLOOD PRESSURE OF BLACKS AND WHITES DERIVED FROM THE DATA SETS OF NHANES I OF 1971-1974

Age (yr)	Race	N	Height (cm)		Weight (kg)		log (body mass index)		Sum of skin folds (mm)		Systolic blood pressure		Diastolic blood pressure	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Males</i>														
20-24	W	421	176.9	7.2	75.6	13.3	1.38	0.07	25.3	12.5	124.9	13.2	76.9*	10.4
	B	80	175.5	7.2	74.4	14.9	1.38	0.07	23.5	14.4	125.8	16.1	80.2	10.5
25-34	W	664	176.9**	7.1	79.4	13.9	1.40	0.06	28.2	12.5	124.9	13.8	80.6	9.9
	B	113	174.7	7.1	78.1	19.3	1.40	0.09	25.9	17.2	127.2	13.5	82.4	10.9
35-44	W	554	175.7	6.7	80.1	12.9	1.41	0.06	28.5	11.3	126.5**	14.2	84.0**	11.0
	B	79	174.5	7.2	79.9	16.6	1.41	0.08	28.9	15.4	135.9	19.2	90.7	13.3
45-54	W	636	174.8	6.7	78.9	13.5	1.41	0.07	28.8*	11.8	133.1**	19.2	86.4**	12.3
	B	116	174.4	7.0	77.5	15.0	1.40	0.08	26.0	13.5	139.2	25.2	90.9	15.2
55-64	W	431	173.3	6.7	77.9	13.9	1.41	0.07	28.0	11.7	137.5*	20.4	85.3**	11.5
	B	69	173.1	6.6	78.2	17.8	1.41	0.08	26.5	14.5	144.2	24.6	90.9	14.4
65-74	W	1098	171.0	6.7	74.1**	12.4	1.40**	0.07	27.2**	11.4	143.3**	23.1	83.8**	12.6
	B	221	170.9	6.6	71.3	13.4	1.38	0.07	23.8	12.7	153.8	28.3	88.6	13.9
<i>Females</i>														
20-24	W	951	162.8	6.4	60.3**	12.7	1.35**	0.08	35.3*	15.5	115.3	12.8	72.0	10.1
	B	255	162.2	6.3	63.5	15.0	1.37	0.09	37.8	18.3	114.8	14.4	73.3	11.4
25-34	W	1524	162.6	6.3	62.7**	14.0	1.37**	0.08	38.8**	16.8	116.7**	13.9	74.9**	10.4
	B	315	162.7	5.7	69.3	17.8	1.41	0.10	45.3	20.7	121.0	17.7	79.0	12.5
35-44	W	1240	162.6	6.4	65.6**	14.5	1.39**	0.08	42.1**	16.8	121.8**	17.0	78.6**	10.9
	B	283	162.9	6.4	74.5	17.8	1.44	0.10	51.3	20.2	129.2	20.2	85.6	13.0
45-54	W	742	161.7	6.1	66.9**	14.2	1.40**	0.08	45.4**	16.8	129.2**	20.2	81.6**	11.8
	B	130	162.5	5.9	74.7	16.6	1.44	0.09	53.5	21.3	141.9	27.9	90.1	14.1
55-64	W	439	159.6	6.1	65.7**	13.2	1.40**	0.08	43.5**	16.0	140.5**	24.1	84.6**	12.1
	B	74	160.4	7.0	73.9	19.2	1.45	0.10	51.5	20.4	150.7	28.2	90.5	14.5
65-74	W	1039	158.3	6.1	64.6**	13.0	1.40**	0.08	41.2**	14.8	148.0**	23.8	84.2**	12.1
	B	193	159.1	6.1	70.0	16.0	1.43	0.09	45.9	17.5	160.6	27.6	88.9	14.9

among whites are systematically lower than among blacks, which indicates that the intake of potassium relative to sodium is less in blacks than in whites. In contrast, Table 2 indicates that the systolic and diastolic blood pressures after the age of 35 years are significantly higher in blacks than in whites. It must be noted that the differences in blood pressure are not associated with concomitant differences in daily calorie intake, sum of skinfolds, or body size.

Because of the differences in Na/K ratio, the comparisons of blood pressure between blacks and whites were adjusted for the effect of this variable by analyses of covariance. Table 3 shows that the tendency toward increased blood pressure of blacks continues even when the effects of the differences in the Na/K ratio are corrected.

DISCUSSION

The present findings are unexpected in that the 24-hr dietary recall indicates that blacks have a lower, not higher, intake of sodium than do whites. These findings differ from

TABLE 3. COMPARISON OF BLOOD PRESSURE ADJUSTED FOR DIFFERENCES IN SODIUM/POTASSIUM RATIO OF BLACKS AND WHITES DERIVED FROM THE DATA SETS OF NHANES I OF 1971-1975¹

Age (yr)	Males							Females						
	Whites			Blacks			F Test	Whites			Blacks			F Test
N	Mean	SE	N	Mean	SE	N		Mean	SE	N	Mean	SE		
<i>Systolic blood pressure</i>														
20-24	421	124.8	0.93	80	125.5	2.12	0.10	949	115.2	0.62	251	114.7	1.20	0.14
25-34	662	124.9	0.74	109	127.0	1.82	1.15	1512	116.7	0.49	312	120.9	1.08	12.32**
35-44	551	126.5	0.81	79	135.7	2.14	16.33**	1239	121.8	0.54	281	129.1	1.13	33.71**
45-54	581	133.5	0.79	108	139.3	1.83	8.45**	626	130.0	0.76	97	143.7	1.93	43.61**
55-64	430	137.5	0.92	69	144.1	2.29	7.32*	439	140.6	0.91	71	150.7	2.25	17.35**
65-74	1093	143.3	0.57	221	153.6	1.28	53.92**	1034	148.1	0.59	190	160.6	1.38	69.53**
<i>Diastolic blood pressure</i>														
20-24	421	76.9	0.57	80	80.1	1.30	5.11*	949	72.0	0.38	251	73.3	0.73	2.39
25-34	662	80.6	0.45	109	82.3	1.11	2.00	1512	74.9	0.30	312	79.0	0.66	31.45**
35-44	551	83.9	0.49	79	90.6	1.31	22.87**	1239	78.7	0.33	281	85.6	0.69	81.04**
45-54	581	86.6	0.48	108	90.9	1.11	12.50**	626	81.7	0.46	97	90.4	1.18	47.14**
55-64	430	85.3	0.56	69	90.9	1.40	13.68**	439	84.6	0.55	71	90.5	1.38	15.89**
65-74	1093	83.8	0.35	221	88.5	0.78	30.22**	1034	84.3	0.36	190	88.9	0.84	25.69**

¹Adjusted through analysis of covariance.
*p < 0.05, **p < 0.005.

previous reports [1–5]. In view of the fact that the present analyses are based upon a large and representative American sample [12–13] and assuming that any errors associated with the collection of the 24-hr dietary recall data were randomly distributed across all samples [13], it can be concluded that blacks do not have an increased dietary intake of sodium. They do have, however, a higher ratio of sodium to potassium intake, which agrees with previous studies [14–16]. It has been postulated that the higher blood pressure of blacks is related to this higher Na/K ratio [14–19]. The finding that blacks adjusted for differences in Na/K ratio did continue to maintain higher blood pressure than whites indicates that the increased prevalence of hypertension in blacks cannot be explained solely on the basis of differences in Na/K ratio.

A major concern in all population studies is the reliability and representativeness of 24-hr dietary measurements. To validate any assessment of dietary sodium intake, one would need information on urinary sodium excretion. Unfortunately, urinary sodium excretion was not measured in NHANES I, and even had such a measurement been obtained it still would not be sufficient. This is because it has been estimated that eleven 24-hr periods of dietary assessment and collection would be necessary to typify individual sodium intake and produce correlations with urinary excretion data [20]. Obviously, such a type of measurement cannot be done in a large survey such as the present one.

Although the differences in blood pressure between whites and blacks in the present study cannot be attributed to differences in Na/K ratio, it is conceivable that blacks are more sensitive to the effects of sodium on blood pressure than whites. Helmer [21] and later Gleibermann [22] postulated that since blacks evolved in the hot environment of the African continent conducive to copious sweating and salt loss and the lack of sodium available in natural foods, they may have evolved more efficient mechanisms of conserving sodium. This state would have been adaptive in non-industrialized populations but may be maladaptive in an environment where dietary sodium is high. This hypothesis is supported by experimental studies indicating that when given a normal i.v. saline solution, blacks excreted salt more slowly than whites [23]. Furthermore, when blacks and whites were given high dietary intakes of sodium, significant increases in blood pressure in the blacks occurred at a sodium intake of 800 mEq/day and at 1200 mEq/day for whites [24]. In other words, the threshold at which blood pressure increases with salt intake is lower in blacks than whites.

In agreement with previous reports [6–7], the present study indicates that blacks ingest less potassium than whites. It is quite possible that the low potassium intake along with an increased susceptibility to salt may be important in the development of hypertension in both blacks and whites. The genetic mechanism associated with this increased sensitivity in blacks remains to be defined. One productive way to do this would be to determine the interrelationship of genetic markers, nutritional factors and blood pressure. In view of the fact that skin color is genetically determined and its phenotypic expression shows great variability, evaluating the relationship of this variability to blood pressure and environmental factors will provide valuable information toward the clarification of the nature-nurture problem of high blood pressure.

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