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Blood Pressure and Hair Cadmium, Lead, Copper, and Zinc Concentrations in Mississippi Adolescents

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Increased cadmium and lead tissue concentrations have been associated with deaths resulting from heart disease (Voors et al. 1982; Beevers et al. 1976 a and b; Voors and Shuman 1977). Hair cadmium levels in babies of hypertensive mothers were 3 times as high as in the hypertensive mothers (Huel et al. 1981). Revis et al. (1981) demonstrated that lead and cadmium could induce aortic atherosclerosis and hypertension in pigeons. Liver cadmium concentrations and aortic lead levels have been reported to be higher in deaths resulting from heart related disease compared to non-heart related disease (Voors et al. 1982). Essential trace elements such as copper and zinc have also been postulated as playing a role in coronary heart disease (Klevay 1975).

The objective of this study was to evaluate the concentrations of hair lead, cadmium, copper, and zinc in Mississippi adolescents and to determine if these hair elements were associated with blood pressure.

METHODS AND MATERIALS

Adolescents were residents of Mississippi who at the time of the study were attending a 4-H conference at Mississippi State University. The adolescents came from throughout the state and ranged in age from 13 to 19 years. Parents were notified ahead of time of the study and signed an informed consent agreement. Subjects reported to a central location of the Mississippi State University campus to have their sex, race, age, weight, height, triceps skinfold thickness, blood pressure, and county of residence recorded. A weight/height index was calculated for each subject. Blood pressure was recorded in the sitting position with an electronic sphygmomanometer (Dyna-Med Inc., Carlsbad, CA). Hair samples were obtained from subjects as described below.

Hair samples were removed from the suboccipital portion of the head with a pair of stainless steel scissors. At least the 1 cm portion closest to the scalp was obtained, but no more than 1 inch from the scalp. Samples were stored in envelopes until washing and analysis.

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The hair washing procedure was based on a published method(McKenzie 1978). Hair was washed by placing samples on Whatman filter paper number 1 in a Buchner funnel and adding 0.1 M EDTA. The solution was drained and rinsed with 2 successive aliquots of deionized-distilled water. Suction was applied to remove moisture. Hair was carefully transferred to acid-washed glass beakers, covered with watch glasses and dried in a vacuum oven for 48 h at 30°C, 30 mmHg. After drying, samples were weighed and wet ashed with a 5 ml nitric acid and 1 ml perchloric acid solution. In most cases, hair samples ranged from 100-500 mg. Ashing continued until white fumes evolved. The ashed samples were transferred to 10 ml volumetric flasks and brought up to volume with deionized-distilled water. Zinc and copper concentrations were determined on a Perkin-Elmer flame atomic absorption spectrophotometer (Model No. 2380, Norwalk, CT). A Perkin-Elmer graphite furnace (HGA-400, Norwalk, CT) was used to quantify lead and cadmium. Results were expressed as parts per million (ppm).

Harvey's least squares analysis of variance was used to determine sex, race, and sex-race differences in hair element concentration and blood pressure (Harvey 1976). Duncan's New Multiple Range Test was used to separate means where significant F values were obtained for sex-race combinations. Simple correlation coefficients were calculated for evaluating variables with blood pressure (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Males had higher systolic, diastolic, and pulse pressures than females and whites had higher diastolic pressure than blacks (Table 1). Males had higher concentrations of hair lead and cadmium than females. Blacks had higher concentrations of hair lead and cadmium than whites. Black males had higher hair cadmium and lead concentrations than other sex-race combinations. Black females had higher hair cadmium concentrations than white males. White males had lower hair copper concentrations than white females and black males. Copper values obtained were comparable to values reported by some investigators (Deeming and Weber 1978; Baumslag 1974) but are higher than reported by others (McKenzie 1978; Klevay 1970). One study has suggested an elevation in heart and kidney cortex copper levels in cardiovascular disease patients (World Health Organization 1974). Borgman et al (1982) observed elevated lead and copper in South Carolina adolescents living in counties with a high incidence of hypertension. Black males had hair lead concentrations which would be considered high (Jenkins 1979).

Weight/height index and triceps thickness generally were positively correlated with systolic pressures with the exception of black males in which no correlation with weight/height index was evident (Tables 2 and 3). Pulse pressures were correlated with weight/height index in whites only. White males had a positive correlation for pulse pressures with triceps thickness. Hair lead and cadmium concentrations were positively correlated with diastolic pressure in white

Table 1. Hair element concentration and blood pressure by sex, race, and sex-race(Mean ±S.E.)[1]

Class	N	Zinc (ppm)	Copper (ppm)	Lead (ppm)	Cadmium (ppm)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)
Sex								
Male	109	245 ±41	77 ±10	30.0 ±3.5 a	1.56 ±.17 A	125.7 ±1.3 a	69.7 ±1.1 a	60.5 ±1.5 a
Female	130	317 ±32	80 ±8	11.1 ±2.8 b	1.09 ±.14 B	118.7 ±1.0 b	65.3 ±1.3 b	49.1 ±1.2 b
Race								
White	150	284 ±30	77 ±10	7.5 ±2.6 a	0.82 ±.13 a	123.4 ±1.0	69.4 ±1.0 A	54.1 ±1.1
Black	89	278 ±42	72 ±8	34.4 ±3.7 b	1.84 ±.18 b	121.1 ±1.4	65.7 ±1.4 B	55.5 ±1.5
Sex-Race								
White Male	82	276 ±40	54 ±10 B	7.6 ±3.5 b	0.70 ±.17 C	127.8 ±1.3	67.0 ±1.3	61.0 ±1.5
White Female	68	291 ±44	91 ±11 A	7.5 ±3.8 b	0.93 ±.19 B C	118.9 ±1.4	71.7 ±1.5	47.2 ±1.6
Black Male	27	214 ±70	100 ±18 A	54.1 ±6.1 a	2.43 ±.30 A	123.6 ±2.3	63.6 ±2.3	60.0 ±2.6
Black Female	62	342 ±46	69 ±12 A B	14.7 ±4.0 b	1.25 ±.20 B	118.6 ±1.5	67.7 ±1.5	51.0 ±1.7

[1]Means with different letter are statistically different within sex, race, or sex-race classes. Upper case letters denote $P \leq 0.05$, lower case letters denote $P \leq 0.01$. Duncan's New Multiple Range test used for sex-race differences.

Table 2. Significant correlation coefficients for physical and hair element concentrations with blood pressure in white subjects.

	Males(N=82)			Females(N=68)		
	Systolic	Diastolic	Pulse	Systolic	Diastolic	Pulse
Weight/Height	.48**	NS	.33**	.32**	NS	.26**
Triceps Thickness	.28*	NS	.25*	.32*	NS	NS
Zinc	NS	NS	.24*	NS	NS	NS
Copper	NS	NS	NS	NS	NS	NS
Lead	NS	NS	NS	NS	.24*	NS
Cadmium	NS	NS	NS	NS	.25*	-.25*

*$P \leq 0.05$
**$P \leq 0.01$

Table 3. Significant correlation coefficients for physical and hair element concentrations with blood pressure in black subjects.

	Males(N=27)			Females(N=62)		
	Systolic	Diastolic	Pulse	Systolic	Diastolic	Pulse
Weight/Height	NS	NS	NS	.27*	NS	NS
Triceps Thickness	.39*	NS	NS	.25*	NS	NS
Zinc	NS	NS	NS	NS	NS	NS
Copper	NS	NS	NS	NS	NS	NS
Lead	NS	NS	NS	-.27*	NS	NS
Cadmium	NS	NS	NS	NS	NS	NS

*$P \leq 0.05$
**$P \leq 0.01$

females. However, hair lead concentrations were negatively correlated with systolic pressure in black females and hair cadmium levels were negatively correlated with pulse pressures in white females.

Hypertension usually develops over a lifetime period. In Mississippi the incidence of hypertension and diseases associated with it are higher in blacks than whites according to the Mississippi Affiliate of the American Heart Association. The increased levels of lead and cadmium observed in blacks, and in particular black males may reflect the initial stages of insult. Moonshine alcohol and cigarette smoking are possible sources of lead and cadmium respectively (Voors et al. 1982), but it is unknown if these sources would be the origin in this age group. Information on drinking and smoking habits for these adolescents may be of value. Water supply, plumbing, and food source could contribute to greater cadmium and lead intakes (Voors et al. 1982). The increased levels of cadmium and lead observed in blacks from this study is cause for concern in light of results from other studies suggesting a relationship between heart disease and these same elements (Voors et al. 1982; Jenkins 1979). In this age group, an overweight condition appeared to have the greatest influence upon blood pressure. Future studies should concentrate on the source of these elements in the environment. Other populations, both normotensive and hypertensive, as well as those suffering from other cardiovascular diseases, should be evaluated for levels of these elements in hair, blood, and other tissues from post-mortem studies.

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