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Relationship of Change in Body Mass to Blood Pressure Among Children in Korea and Black and White Children in the United States

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Body mass is a major factor in determining blood pressure levels in children. We compared associations of body mass with blood pressure in 121 white and 91 black children in Bogalusa, Louisiana with that of 370 children in Kangwha, Korea. All children were seven years old at entry into the study and were followed for three years. Korean children were shorter ($p<0.001$), thinner ($p<0.0001$), and had a lower body mass index ($p<0.01$) than white or black children. At age seven, systolic blood pressure levels were 2~5 mm Hg lower, but at age 10, they were 2~5 mm Hg higher in Korean than white or black children. The increases in blood pressure levels from age seven to ten years were much greater in Korean than black or white children, while changes in height, weight, and body mass index were generally less. Change in blood pressure level was positively associated with change in body mass index for systolic (but not diastolic) levels; however, the association was no stronger for Korean than for U.S. children, except for Korean males vs Bogalusa black males. Cross-cultural studies of other factors, such as diet and physical activity, may explain these differences.

Key Words: Blood pressure, child growth, longitudinal studies, obesity

Hypertension is one of the most common cardiovascular diseases and has been recognized as an important factor in the occurrence of congestive heart failure, cerebrovascular accidents, and coronary heart disease. Essential hypertension, most commonly diagnosed in adults, may have its origin in childhood. The level of blood pressure in childhood is important, since levels can track and determine blood pressure levels in adulthood (Berenson, 1986; Lauer and Clarke, 1989). Many have reported this tracking phenomenon or tendency of blood pressure level for an individual to rank consistently over time relative to the entire population (Voors *et al.* 1980; Szklo, 1986). In childhood, an increase in blood pressure with age is a common phenomenon among all ethnic groups, but the level of blood pressure at certain ages and the rate of change in blood pressure may be different according to ethnic origin (Gliksman *et al.* 1990; de Man *et al.* 1991). Among factors which determine the level of blood pressure in children, body mass is known to be a major factor (Berenson, 1986). Also the change of body

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mass during childhood has been reported as a strong predictor of blood pressure level in adults (Lauer *et al.* 1984; Lauer and Clarke, 1989). Therefore, it is valuable to document the relative importance of body mass to the level and change of blood pressure of children for various ethnic groups. If there were a difference among ethnic groups, then there would be a need to identify whether the difference is environmental, genetic, or both.

A population-based prospective study of blood pressure of children in Korea, the Kangwha Children's Blood Pressure Study, showed that in cross-sectional analysis Korean children were usually thin and had low body mass and body fat in comparison with published findings on children of the same age in the United States (Suh *et al.* 1989). However, the level of blood pressure of Korean children was higher than that of children in the United States, and the average annual increase of blood pressure was also larger than that of children in the United States. This somewhat contradicting phenomenon can be suspected as an ethnic difference.

This study aims to compare the association of body mass with blood pressure in white and black children living in the United States with that in Korean children using longitudinal follow-up data. The specific objectives are: 1) to compare the association of body mass with the level of blood pressure in three ethnic groups; and 2) to compare the effect of change in body mass from seven to ten years of age on the change of systolic and diastolic blood pressure among three ethnic groups.

MATERIALS AND METHODS

Kangwha Children's blood pressure study

A population-based prospective study of blood pressure in children in Korea, the Kangwha Children's Blood Pressure Study, started in 1986 with 430 first-grade children in elementary schools located in a rural area (Kangwha County). The mean age of children at the first examination was seven years. Annual follow-up examinations were performed by senior medical students through 1989. All the examinations were performed in June at the elementary school which participants attended. Height, weight, right upper arm circumference, pulse rate, triceps skinfold thickness, systolic blood pressure, and diastolic blood pressure (Korotkoff phase 4 and 5) were measured.

One master trainer (Il Suh) trained all the observers each year from 1986 through 1989. Observers were trained to measure blood pressures using a double stethoscope and the training manual, slides, and videotapes from the "Program on Epidemiology and Blood Pressure in Childhood, Youth and Early Adulthood" of the University of Texas in Houston (Personal communication-Dr. Darwin Labarthe). After the training, the performance of the observers was examined by the Emory Videotape Scoring Procedure. This included 11 scenes (four in duplicate) of a blood pressure videotape in which observers scored systolic and fourth-phase diastolic blood pressures. Observers were certified only when they met the criteria adopted for the Hawaii Heart Association Project, i.e., the sum of deviations from correct values had to lie between +11 and −11 mmHg. In addition, three of the four pairs must agree within 4 mmHg. These criteria were applied separately for systolic and diastolic blood pressure readings. Standard mercury manometers were used, and bladder size of cuffs were 9×22 cm except when arm circumference of a child exceeded 22.6 cm. When it exceeded this value, cuffs with bladder size of 12×22 cm were used. Blood pressures were measured twice by different observers in the right arm after the child was seated for 10 minutes in a quiet room.

Before the first blood pressure measurement, arm length and circumference were measured with a metric cloth measuring tape. Height, weight, triceps skinfolds thickness, and pulse rate were measured between the first and second blood pressure measurements. Triceps skinfolds were measured every year except in 1986. A Japanese caliper (Meikosha Co., Japan, Eiyoken type) was used for the measurement of skinfolds thickness. A single, different observer made these measurements

in each year of examination. Height was measured using a height board made in Korea, while weight was measured using a spring balance scale made in Korea.

Bogalusa heart study

The Bogalusa Heart Study is a long-term epidemiological investigation of cardiovascular risk factors from childhood to young adulthood (Berenson *et al.* 1980). Since 1973 over 12,000 different subjects have been measured. Detailed protocols have been maintained for all examinations. Training and evaluation sessions were conducted three to four times a year under the auspices of a master trainer. The same master trainers have been available through the course of the study. Nurse-examiners failing to meet pre-established criteria did not take measurements in the study. Only subjects who averaged seven years of age (6-1/2 to 7-1/2 years) in the 1981~1982 survey who were reexamined in the 1984~1985 survey were included in these analyses. All measurements were taken at the school site from September through May each year and individuals generally were measured at the same season each year.

Height was measured twice to the nearest 0.1 cm on a standard height board built at the University of Iowa, and weight was measured twice on a balance beam scale (Detecto Sales, Inc., Brooklyn, NY, U.S.A.) (Foster *et al.* 1977). In order to compare the results to the data obtained in Korea, only the results from the first measurement were used in these analyses.

Prior to blood pressure measurement, right upper arm length and circumference were measured using a GPM anthropometer (Siber Precision, Inc., Carlstadt, NJ, U.S.A.) and metal measuring tape, respectively (Foster *et al.* 1977). The appropriate blood pressure cuff was selected based on both arm length and circumference (Voors, 1975). The cuff sizes were the same as in the Kangwha study with only modest differences in the cuff selection protocol.

Blood pressure was measured nine times, three readings by each of three trained examiners. Two examiners used a standard mercury sphygmomanometer, and the third used a Physiometrics automatic blood pressure measuring device (Voors *et al.* 1976). In order to compare data from Bogalusa with those from Korea, only the first and second reading from the first mercury sphygmomanometer station were analyzed. Systolic, fourth phase and fifth phase diastolic readings were obtained. All measurements were observed while the child was seated in a quiet room. The first measurement was taken after a five-minute rest. Subsequent readings were taken one minute apart.

Data analyses

Height, weight, body mass index, systolic blood pressure, and diastolic blood pressure (fourth and fifth phase) by ethnic group for seven and ten years-old boys and girls were compared. The associtions between the level of BMI and levels of blood pressures were compared according to ethnic group, sex, and age. Also the changes in anthropometric measures and blood pressure levels from age seven to ten years were compared in three ethnic groups.

For all values of blood pressure, the average of the first and second measurement was used in the analyses. Analysis of variance techniques and the Student Newman Keuls Multiple Comparison Test (Snedecor and Cochran, 1980) were used to compare anthropometric and blood pressure readings among the three ethnic groups for each gender at each age. The changes in blood pressures and body mass were calculated from the difference between the values at seven and 10 years of age. Pearson correlation coefficients were calculated between the level of body mass and the level of blood pressure. Body Mass Index (BMI) is defined as weight (kg) divided by height squared(m^2). A χ^2 test of homogeneity was used to compare the correlation coefficients among the three ethnic groups by gender (Sokal and Rohlf, 1981). An analysis of covariance model was used to compare the increases from age seven years to ten years for the three ethnic groups. Covariates were height at seven years, change in height from age seven to ten years, BMI at

age seven years, and change in BMI from age seven to ten years. Regression coefficients were calculated for the linear regression of change in blood pressure from ages seven to ten years on the change in BMI from ages seven to ten years and compared using Analysis of Variance procedures (Kleinbaum *et al.* 1988). Two-tailed tests were used for all comparisons

RESULTS

Population

In Kangwha, 211 male and 219 female children were examined as seven-year-olds in 1986. This represents 91% of the 469 eligible children. By 1989, 185 of the males (88%) and 185 of the females (84%) remained in the cohort and were examined as 10-year-olds.

In Bogalusa, a total of 284 subjects (91% of the eligible population) were examined in 1981-82. There were 212 white or black children of seven years of age during the 1981-82 survey who were reexamined in 1984-85 at 10 years of age. There were 60 white boys, 61 white girls, 41 black boys and 50 black girls.

Anthropometric and blood pressure levels in three ethnic groups

Table 1 shows the level of height, weight, BMI, systolic blood pressure, and diastolic blood pressures (fourth and fifth phase) by ethnic group for seven-year-old boys and girls. Korean children were shorter ($p<0.001$), weighed less ($p<0.0001$), and had lower BMI ($p<0.01$) than white and black children of both sexes. The level of systolic blood pressure in Korean children was 2~5 mm Hg lower than those in white and black children ($p<0.05$ for comparison with white males only); however, the three ethnic groups showed similar levels of diastolic blood pressures (although levels tended to be highest in blacks).

Three years later, the levels of height, weight, and BMI of Korean children were still lower than those of white and black children (all $p<0.01$). The levels of systolic blood pressure were higher for Korean males than for white (NS) or black ($p<0.01$) males, and

Table 1. Anthropometric and blood pressure levels by ethnic group at age seven years

		Korean			White			Black		
	Unit	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
					Males					
Height	cm	185	118.3[h]	4.7	60	121.3[b,g]	5.8	41	123.4[a,g]	5.2
Weight	kg	185	21.0[h]	2.8	60	24.3[g]	4.8	41	24.3[g]	4.4
BMI	Kg/m^2	185	15.0[d,h]	1.3	60	16.3[g]	2.0	41	15.9[c]	2.0
SBP	mm Hg	184	93.3[b]	9.2	60	98.3[a]	7.1	41	96.2	8.9
DBP4	mm Hg	184	57.2	7.2	60	57.7	7.3	41	59.7	8.2
DBP5	mm Hg	180	46.8	7.9	60	44.7	10.3	41	48.4	10.2
					Females					
Height	cm	185	117.3[f,h]	4.6	61	120.4[e]	6.0	50	121.9[g]	5.2
Weight	kg	185	20.0[h]	2.3	61	24.1[g]	5.7	50	23.2[g]	4.1
BMI	kg/m^2	185	14.5[h]	1.1	61	16.5[g]	2.6	50	15.8[g]	1.9
SBP	mm Hg	185	93.2	10.1	61	96.7	7.3	50	95.2	8.6
DBP4	mm Hg	184	59.1	8.3	61	59.0	8.7	50	60.1	6.7
DBP5	mm Hg	183	48.4	9.1	61	46.1	12.2	50	48.5	8.1

SD: standard deviation; BMI: body mass index, SBP: systolic blood pressure, DBP4: diastolic blood pressure (fourth phase), DBP5: diastolic blood pressure (fifth phase); ethnic comparisons by gender for each variable; a>b, $p<0.05$; c>d, $p<0.01$; e>f, $p<0.001$; g>h, $p<0.0001$.

higher for Korean females than for black or white females ($p<0.05$)(Table 2). Fourth phase and fifth phase diastolic blood pressures were significantly higher in Korean than in white and black children ($p<0.0001$).

Level of BMI and blood pressures

The associations between the level of BMI and levels of blood pressures appeared to be different according to ethnic group, sex, and age(Table 3). Except for Korean and black females at age seven, BMI was significantly associated with systolic blood pressure for the three ethnic groups. A test of homogenity among the correlation coefficients showed that there was no significant difference in the magnitude of the correlation coefficients among the three ethnic groups for systolic, fourth-phase or fifth-phase readings for males at either age. For females at age seven years, the correlation between BMI and diastolic blood pressure levels was signficantly higher among whites than Koreans ($p<0.05$). No other differences in the correlation coefficients for females at either age were noted. In general, associations with systolic and diastolic blood pressures were more consistent at age 10 than age seven years, especially in females.

Change of BMI and the change of blood pressures

The changes in anthropometric measures and blood pressure levels from ages seven to 10 years differed for the three ethnic groups (Tables 4 and 5). For males, the increase of height was about 1.2~2.1 cm greater in black and white males than in Korean males ($p<0.001$). The increase of weight was 3.8 kg greater in whites ($p<0.01$) and 2.5 kg greater in blacks ($p<0.01$) than Korean males. Although both white and black males had a greater increase of BMI than Korean males, the increase was significantly greater for whites only. A much greater increase of blood pressure levels (adjusted for height and BMI at

Table 2. Anthropometric and blood pressure levels by ethnic group at age ten years

		Korean			White			Black		
	Unit	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
						Males				
Height	cm	185	134.2^{f}	5.8	60	139.4^{e}	6.7	41	140.6^{e}	6.3
Weight	kg	185	30.0^{f}	5.4	60	37.0^{e}	9.5	41	35.8^{e}	9.7
BMI	Kg/m^2	185	16.5^{a,f}	2.1	60	18.8^{e}	3.5	41	17.9^{c}	3.8
SBP	mm Hg	185	103.8^{c}	9.1	60	101.8	8.0	41	99.2^{d}	8.5
DBP4	mm Hg	185	70.7^{e}	8.4	60	61.0^{f}	8.1	41	59.8^{f}	9.6
DBP5	mm Hg	185	60.5^{e}	9.4	60	49.1^{f}	10.9	41	46.9^{f}	14.2
						Females				
Height	cm	185	133.7^{f}	5.9	61	139.3^{b,e}	8.2	39	141.6^{a,e}	7.4
Weight	kg	185	29.0^{f}	5.3	61	36.2^{e}	10.6	39	36.4^{e}	9.0
BMI	kg/m^2	185	16.1^{f}	2.1	61	18.4^{e}	3.7	39	17.9^{e}	3.4
SBP	mm Hg	185	105.7^{a}	9.8	61	100.7^{b}	8.9	39	100.6^{b}	9.6
DBP4	mm Hg	185	71.0^{e}	8.2	61	62.6^{f}	9.2	39	62.2^{f}	8.4
DBP5	mm Hg	185	62.3^{e}	9.5	61	52.0^{f}	11.9	39	50.5^{f}	12.9

SD: standard deviation; BMI: body mass index, SBP: systolic blood pressure, DBP4: diastolic blood pressure (fourth phase), DBP5: diastolic blood pressure (fifth phase); ethnic comparisons by gender for each variable; a>b, $p<0.05$; c>d, $p<0.01$; e>f, $p<0.0001$.

Table 3. Correlation coefficients of body mass index with blood pressures by ethnic group and age

	Males			Females		
	Korean (n=185)	White (n=60)	Black (n=14)	Korean (n=185)	White (n=61)	Black (n=50)
	Correlation of BMI at Age Seven Years With Blood Pressure at Age 7 Years					
SBP	0.27***	0.45***	0.32*	0.13	0.45***	0.23
DBP4	0.11	0.20	0.25	−0.07	0.48****	0.20
DBP5	0.09	0.06	0.03	−0.11	0.23	0.07
	Correlation of BMI at Age ten years with Blood Pressure at Age 10 Years					
SBP	0.36****	0.51****	0.33*	0.24**	0.41**	0.46***
DBP4	0.20**	0.33**	0.22	0.12	0.42***	0.25
DBP5	0.14	0.28*	0.17	0.06	0.35**	0.18

BMI: body mass index, SBP: systolic blood pressure, DBP4: diastolic blood pressure (fourth phase), DBP5: diastolic blood pressure (fifth phase). Level of significance to test whether correlation coefficient is squal to zero. *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$, ****: $p<0.0001$

Table 4. Changes in height, weight, body mass index and blood pressure from seven to ten years of age in males by ethnic group

Change in	Males					
	Korean(n=185)		White(n=60)		Black(n=41)	
	Mean	SE	Mean	SE	Mean	SE
Height	$15.90^{f,h}$	0.14	$18.04^{a,g}$	0.32	$17.15^{b,e}$	0.35
Weight	$8.94^{d,h}$	0.25	12.72^{g}	0.74	11.42^{c}	0.90
BMI	1.56^{d}	0.11	2.46^{c}	0.26	2.03	0.34
SBP*	10.45^{g}	0.71	2.37^{h}	1.20	4.35^{h}	1.36
DBP4*	13.57^{g}	0.72	2.34^{h}	1.22	0.52^{h}	1.38
DBP5*	13.83^{g}	0.88	3.91^{h}	1.46	-0.27^{h}	1.66

SE: standard error; BMI: body mass index, SBP: systolic blood pressure, DBp4: diastolic blood pressure (fourth phase), DBP5: diastolic blood pressure (fifth phase); ethnic comparisons for each variable; a>b, $p<0.05$; c>d, $p<0.01$; e>f, $p<0.001$; g>h, $p<0.0001$.

* Adjusted for height (age 7 years), change in height from age 7 to 10 years, BMI (age 7 years) and change in BMI from age 7 to 10 years.

age 7 as well as change in height and change in BMI) was seen in Korean males compared to the Bogalusa white and black males with the difference about 7 mmHg for systolic blood pressure ($p<0.0001$). Few differences were observed in the change of covariate-adjusted blood pressure levels comparing white to black males. For fifth-phase diastolic levels, the increase in covariate-adjusted levels for white males (3.91 mmHg) was significantly greater ($p<0.05$) than the small decrease observed for black males (−0.27 mmHg). Similar results were noted for females (Table 5) with the exception that a significantly greater in-

Table 5. Changes in height, weight, body mass index and blood pressure from seven to ten years of age in males by ethnic group

Change in	Females					
	Korean(n=185)		White(n=60)		Black(n=39)	
	Mean	SE	Mean	SE	Mean	SE
Height	16.41[h]	0.17	18.91[b,g]	0.40	20.00[a,g]	0.57
Weight	8.99[h]	0.26	12.07[g]	0.74	12.79[g]	0.84
BMI	1.62[d]	0.11	1.91	0.23	2.11[c]	0.30
SBP*	13.96[g]	0.79	4.29[h]	1.43	3.84[h]	1.67
DBP4*	13.07[g]	0.78	3.48[h]	1.39	2.65[h]	1.65
DBP5*	14.13[g]	0.93	6.76[h]	1.65	4.08[h]	1.95

SE: standard error; BMI: body mass index, SBP: systolic blood pressure, DBp4: diastolic blood pressure (fourth phase), DBP5: diastolic blood pressure (fifth phase); ethnic comparisons for each variable; a>b, $p<0.05$; c>d, $p<0.01$; e>f, $p<0.001$; g>h, $p<0.0001$.

* Adjusted for height (age 7 years), change in height from age 7 to 10 years, BMI (age 7 years) and change in BMI from age 7 to 10 years.

Table 6. Regression coefficients of change in blood pressure from age seven to ten years on change in body mass index from age seven to ten years by ethnic group

	Males			Females		
	Korean (n=185)	White (n=60)	Black (n=41)	Korean (n=185)	White (n=61)	Black (n=50)
Change in SBP	0.88*[,a]	1.17**[,a]	−0.51[b]	1.10*	0.93	2.15***
Change in DBP4	0.40	0.42	−0.25	0.77	0.50	0.42
Change in DBP5	0.52	0.49	0.15	0.93	0.72	0.23

BMI: body mass index, SBP: systolic blood pressure, DBP4: diastolic blood pressure (fourth phase), DBP5: diastolic blood pressure (fifth phase). Level of significance to test whether regression coefficient is equal to zero. *: $p<0.05$, **: $p<0.01$; ***: $p<0.001$; a>b, $p<0.05$

crease of BMI was noted for black ($p<0.01$) females compared to Korean females. All growth indices increased more in black than white females whereas for males the increases were greater for whites than blacks.

The regression coefficient for change in systolic blood pressure on change in BMI was statistically significant in Korean children in both sexes (males, $\beta=0.88$; females, $\beta=1.10$). For white children the regression coefficient was significant only for boys ($\beta=1.17$), and for black children it was significant only for girls ($\beta=2.15$) (Table 6). For all three ethnic groups, the regression coefficients for change in blood pressure on change in BMI were not significant for either diastolic fourth phase or fifth phase blood pressures, although all but one coefficient were positive. The regression coefficient for change in systolic blood pressure on change in BMI was significantly larger for Korean and white males than for black males ($p<0.05$). No differences were noted for females. No significant differences in the magnitude of the regression coefficients were noted for change in diastolic blood pressure (with 4th or 5th phase) on change in BMI among the three ethnic groups for either males or females.

DISCUSSION

Differences of growth and development among ethnic groups living in different cultures are apparent and may well account for differences in subsequent cardiovascular risk. In this study of black and white children living in a rural community in the southern part of the United States and Korean children in the rural Kangwha province in Korea, differences in their body size measures were observed. At both ages, seven and ten years, the Korean children were consistently 3 to 5 cm shorter than the children in the United States. In addition, the Korean children were about 3~4 kg lighter at age seven and about 7 kg lighter at age ten. Overall, the increase of BMI from ages seven to 10 years was about 1.5 times greater in white children and black children than in Korean children, indicating that the children in Bogalusa were getting proportionally heavier with age for this age span.

Although blood pressure levels were similar at age seven among the three groups, systolic and diastolic readings were higher at age ten years in the Korean than in the US black or white children. Large rises of both systolic and diastolic blood pressure levels of 10~14 mm Hg were observed for the three-year span in the Korean children compared to 4 mm Hg systolic and 3 mm Hg diastolic for the Bogalusa children. These longitudinal changes agree with our earlier observations of differences across age groups in both cross-sectional (Voors *et al.* 1976) and longitudinal (Webber *et al.* 1993) comparisons in Bogalusa blacks and whites.

For all females and for Korean and white males, a positive association was found between change of BMI and change of systolic blood pressure. For black males, no relationship was noted. The magnitudes of the regression coefficients were greatest for white males and black females, which showed the greatest growth during the three-year period.

In general, change in BMI was positively associated with change in systolic blood pressure in three ethnic groups, even though the coefficients for black boys and white girls did not reach statistical significance. This is consistent with findings of Visser *et al.* (Visser *et al.* 1987). and shows the importance of change of BMI as a determinant of rise in systolic blood pressure in each of the three ethnic groups.

Data for both fourth and fifth phase diastolic blood pressure are presented. The correlations between diastolic blood pressure and BMI were lower than those observed between systolic blood pressure and BMI. This may be explained by the difficulty in measurement for diastolic readings particularly for young children (Voors *et al.* 1979).

Comparability of measurements could be a limitation as the two studies had been performed separately. However, this problem should be minimized due to two factors. The first is that our main focus was on the changes of BMI and blood pressure instead of the levels of these variables, and the second is that both studies used well-standardized methods of measurements. Although the follow-up rate was slightly higher in Kangwha (91%) than in Bogalusa (75%), there is likely to be little selection bias. No differences in height, BMI or blood pressure levels were noted between seven year olds who were retained in the Bogalusa Heart Study and those who were not.

In the Kangwha Children's Blood Pressure Study, senior medical students were recruited each year as observers. They completed the same training protocol, thus maintaining the quality of observers and standardization of blood pressure measurement methodology. It should be noted that the standard deviations in Tables 1 and 2 for blood pressure measurements in children in Kangwha were similar to those obtained in the Bogalusa Heart Study.

It might be noted that because blood pressure is highly correlated with linear growth and may be influenced by maturation, future studies of various growth periods are warranted. In addition, studies into young adulthood when linear growth stops, but weight gain continues, might also be useful. In adults, blood pressure levels in Korea have been reported to be similar to those in adults in the

United States (Kim *et al.* 1982). The prevalence of diastolic hypertension (diastolic blood pressure>95 mm Hg) was higher in Korean adults than in adults in the United States, however. Blood pressure levels at the Korean center in INTERSALT were lower than those of U.S. centers (The INTERSALT Cooperative Research Group, 1988); however, this Korean site drew its population from Pusan, a southern coastal city, and the Korean Nationwide Blood Pressure Study reported significantly lower blood pressures among people born in the south compared to those born in the north (Kim *et al.* 1982).

Cross-cultural data on other factors potentially influencing blood pressure levels-especially dietary factors and physical activity-would be very useful. For example, the Korean diet is probably higher in sodium compared to the American diet, while fat, protein and caloric intake are greater in Bogalusa children (The INTERSALT Cooperative Research Group, 1988). However, collection of data regarding children's diets has inconsistently identified the influence of dietary factors on blood pressure (Hofman *et al.* 1983; Gilman *et al.* 1992; Nicklas *et al.* 1993). In spite of these methodologic challenges, intra-population and cross-population studies of lifestyle factors and blood pressure change in children are still important, because of the potential for primary prevention of this condition (Downey *et al.* 1989; Perry *et al.* 1990; Working Group on Primary Prevention of Hypertension, 1993).

REFERENCES

Berenson GS (ed): *Causation of cardiovascular risk factors in children. New York, Raven Press, 1986, 42-64*

Berenson GS, McMahan CA, Voors AW, Webber LS, Srinivasan SR, Frank GC, Foster TA, Blonde CV: Cardiovascular Risk Factors in Children: *The Early Natural History of Atherosclerosis and Essential Hypertension.* New York, Oxford University Press, *1980, 258-273*

de Man SA, Andre JL, Bachmann H, Grobbee DE, Ibsen KK, Laaser U, Lippert P, Hofman A: Blood pressure in childhood: pooled findings of six European studies. *J Hypertens 9: 109-114, 1991*

Downey AM, Cresanta JL, Webber LS, Berenson GS: Cardiovascular health promotion in children: "Heart Smart" and the changing role of the pediatrician. *Am J Prev Med 5: 279-295, 1989*

Foster TA, Voors AW, Webber LS, Frerichs RR, Berenson GS: Anthropometric and maturation measurements of children ages 5 to 14 years in a biracial community-the Bogalusa Heart Study. *Am J Clin Nutr 30: 582-591, 1977*

Gilman MW, Oliveria SA, Moore LL, Ellison RC: Inverse association of dietary calcium with systolic blood pressure in young children. *JAMA 267: 2340-2343, 1992*

Gliksman MD, Dwyer T, Wlodarczyk J: Differences in modifiable cardiovascular disease risk factors in Australian school children: The result of a nationwide survey. *Prev Med 19: 291-304, 1990*

Hofman A, Hazeborek A, Vallenburg HA: A randomized trial of sodium intake and blood pressure in newborn infants. *JAMA 250: 370-373, 1983*

Kim IS, Lee YH, Suh I, Oh HC, Oh DK, Kim SY, Park CD: Korean Nationwide Blood Pressure Study. *Yonsei Med J 23: 15-25, 1982*

Kleinbaum DG, Kupper LL, Muller KT: *Applied regression analysis and other multivariable methods.* Boston, PWS-Kent Publishing Co., *1988, 244-314*

Lauer RM, Clarke WR: Childhood risk factors for high adult blood pressure: The Muscatine Study. *Pediatrics 84: 633-641, 1989*

Lauer RM, Clarke WR, Beaglehold R: Level, trend, and variability of blood pressure during childhood: the Muscatine Study. *Circulation 69: 242-249, 1984*

Nicklas TN, Webber LS, Srinivasan SR, Berenson GS: Secular trends in dietary intakes and cardiovascular risk factors of 10-year-old children-The Bogalusa Heart Study (1973~1988). *Am J Clin Nutr 57: 930-937, 1993*

Perry CL, Stone EJ, Parcel GS, Ellison RC, Nader PR, Webber LS, Luepker RV: School-based cardiovascular health promotion: The Child and Adolescent Trial for Cardiovascular Health (CATCH). *J Sch Health 60: 406-413, 1990*

Snedecor GW, Cochran WG: *Statistical Methods* (7th ed). Ames, Iowa, The Iowa State University Press, *1980, 215-237*

Sokal RR, Rohlf FJ: *Biometry-The Principles and*

Practice of Statistics in Biological Research. 2nd ed. New York, W.H. Freeman and Company, *1981, 691-778*

Suh I, Kim IS, Nam CM, Lee SY, Oh HC, Kim CB, Park EC: The change of children's blood pressure and factors affecting the level of blood pressure in children. *Korean J Prev Med 22: 303-312, 1989*

Szklo M: Determinants of blood pressure in children. *Clin Exp Hypertens [A] 8: 539-545, 1986*

The INTERSALT Cooperative Research Group: INTERSALT: an international study of electrolyte excretion and blood pressure, results for 24 hour urinary sodium and potassium excretion. *Br Med J 297: 319-328, 1988*

Visser MC, Grobbee DE, Hofman A: Determinants of rise in blood pressure in normotensive children. *J Hypertens 5: 367-370, 1987*

Voors AW: Cuff bladder size in a blood pressure survey of children. *Am J Epidemiol 101: 489-494, 1975.*

Voors AW, Foster TA, Frerichs RR: Studies of blood pressures in children ages 5-14 years, in a total biracial community. The Bogalusa Heart Study. *Circulation 54: 319-327, 1976*

Voors AW, Webber LS, Berenson GS: A choice of diastolic Korotkoff phases in mercury sphygmomanometry of children. *Prev Med 8: 492-499, 1979*

Voors AW, Webber LS, Berenson GS: Time course study of blood pressure in children over a three-year period-The Bogalusa Heart Study. In: High Blood Pressure in the Young. *(Hypertension Supplement) 2: 102-108, 1980*

Webber LS, Srinivasan SR, Berenson GS: Epidemiology of early cardiovascular disease-observations from the Bogalusa Heart Study. *Am J Hum Biol 5: 433-450, 1993*

Working Group on Primary Prevention of Hypertension: National High Blood Pressure Education Program: Working Group Report on Primary Prevention of Hypertension. *Arch Intern Med 153: 186-208, 1993*