Resting Pulse Rate of Children and Young Adults Associated with Blood Pressure and Other Cardiovascular Risk Factors

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Synopsis

Few researchers have investigated the resting pulse rate of children and young adults as a risk factor or indicator for subsequent cardiovascular morbidity in a representative sample of the total population.

Data from the first National Health and Nutrition Examination Survey for persons ages 6–24 years revealed mean resting pulse rates that declined with age until ages 12–16, were higher in females than males, and in whites than blacks. At ages 12–17 and 18–24, blood pressure and body temperature showed consistent, independent, positive associations with pulse rate in whites.

However, relatively little of the overall variation in pulse rate was explained by measured variables in multivariate regression analyses. Mother-child, age-specific correlation coefficients for pulse and blood pressure were generally positive. Further research is needed on the associations of resting pulse rate with sex, race, and blood pressure and with subsequent cardiovascular morbidity.

DESPITE THE ASSOCIATION of the resting pulse rate with morbidity and mortality in adults and the ease of measuring it (*1*), few data on rates have been available for representative samples of the total population. Studies of young adults who were followed to middle age suggest that an elevated pulse rate may be an important indicator of cardiovascular risk in children and youth (*2*).

Methods

The first National Health and Nutrition Examination Survey (NHANES I) was conducted in 1971–73 on a nationwide multistage probability sample of 28,043 persons from the civilian noninstitutionalized population ages 1–74 years of the United States. Populations of Alaska, Hawaii, and the reservation lands of the American Indians were excluded. Seventy-four percent of the sample, 20,749 persons, were examined. This report is restricted to white and black children and young adults ages 6–24 years with valid pulse rate measurements. The 2,024 children ages 6–11 included 507 blacks and 1,016 females. The 4,213 persons ages 12–24 years included 928 blacks and 1,864 females. The 115 pregnant females in the 15–24-year group were excluded. Numbers of persons in several analyses that follow vary because the numbers of missing values differed for selected variables. Details of the plan, sampling, operation, and response have been published as have procedures used to obtain informed consent and to maintain confidentiality of information obtained (*3,4*).

Demographic, medical history, and behavioral information was collected prior to the examination during the household interview of the parents or guardians of children and of adult participants ages 18 and older. The following questions on habitual physical activity were asked concerning the 12–24-year-olds:

1. "Do you get much exercise in things you do for recreation (sports, or hiking, or anything like that), or hardly any exercise, or in between?"
2. "In your usual day, aside from recreation, are you physically very active, moderately active, or quite inactive?"

Also included were questions on alcohol intake but not on smoking (*4*).

Examinations were carried out in a mobile examination center. Oral temperatures were taken shortly after the subjects arrived at the examination site and were reported to the staff physician if greater than 101 degrees Fahrenheit (38.3 degrees Celsius). At the beginning of the examination, the physician counted the radial pulse for at least 30 seconds with the examinee sitting and recorded it on the standard examination form as beats per minute (*3*).

Next, the physician measured blood pressure with the examinee seated, using a standard sphygmomanometer of the mercury type at 52 examination center locations or of the aneroid type at 13 locations. An adult 13-centimeter cuff or a pediatric 9.5-centimeter cuff was used as appropriate. For diastolic pressure, the level was recorded at the level of complete cessation of Korotkoff's sounds or, if there was no cessation, at the point of muffling. Measurements were recorded to the nearest 2 millimeters on the scale. Blood pressure was measured in the right arm with the bell of the stethoscope used for auscultation. Blood pressure measurements using aneroid instruments did not differ significantly from those obtained with mercury instruments.

The proportion of subjects not measured ranged from 25 percent at 6 years to 1.4 percent at 7-11 years and to less than 1 percent at 12-24 years. Estimates of missing measurements were made for those persons ages 7-24 years. Because such a large proportion of the blood pressures among the 6-year-olds were not recorded due to an error in interpreting the examination form, no imputations were made for them when both values were missing (*5*).

The double product of blood pressure (BP) and pulse rate was calculated two ways: (*a*) ((systolic BP + 2 × diastolic BP) ÷ 3) × pulse rate and (*b*) systolic BP × pulse rate. Blood samples were obtained and hemoglobin concentration determined in duplicate at the examination center (*6*). Serum cholesterol determinations were made at the Centers for Disease Control, Public Health Service, using a modified ferric chloride technique (*7,8*).

Technicians measured height to the nearest 0.1 centimeter, weight to the nearest 0.25 pounds, triceps and subscapular skinfold thickness to the nearest 0.1 millimeter, and took an X-ray of the hand and wrist for assessment of skeletal age in 6–17-year-old children (*9*).

A series of variables assigned in the sample selection process and a variable indicating relationships to the head of household from the home interview enabled analysis of related persons in the sample. However, in order to form mother-child pairs, certain assumptions had to be made. It was assumed that if the head of household was male, the woman designated as the wife of the head of household was the mother of the head of household's child. If the head of household was female and was examined, then she was the mother of the child of the head of household. It was not possible to establish whether the children were biological offspring, adopted, stepchildren, or foster children. To enhance the likelihood of children being biological offspring, three groups were excluded in the family analyses: (*a*) children whose race was reported as different from that of the mother, (*b*) 6-11-year-olds whose mothers were 45 or older, and (*c*) 12-17-year-olds whose mothers were 55 or older.

Further, the number of possible fathers examined was small and, since the likelihood of the male head of household not being the biological father of the child was probably relatively high, the family analysis was restricted to mother-child pairs.

Figure 1. Mean resting pulse rate of males ages 6–24 years, United States, 1971–73

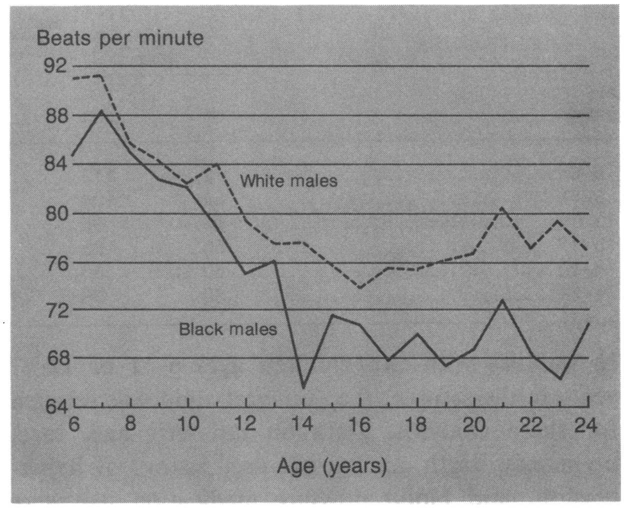

Figure 2. Mean resting pulse rate of females ages 6–24 years, United States, 1971–73

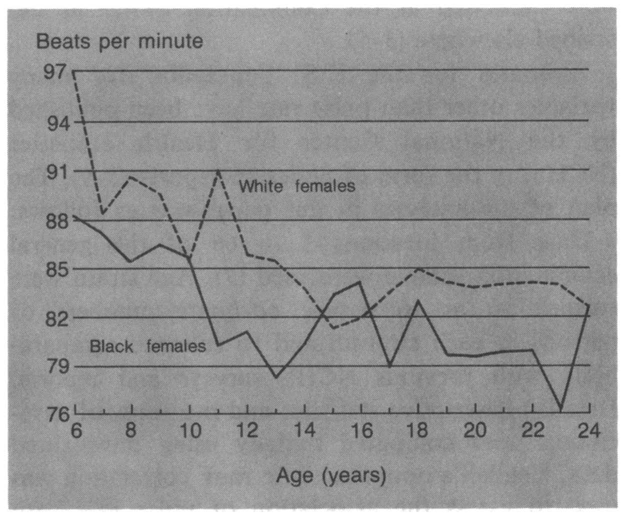

Table 1. Estimates of the resting pulse rate (beats per minute) of the 5th percentile and the 95th percentile of children and young adults, First National Health and Nutrition Examination Survey, by age, sex, and race, 1971-73

	Males				*Females*			
	White		*Black*		*White*		*Black*	
Age (years)	*5th*	*95th*	*5th*	*95th*	*5th*	*95th*	*5th*	*95th*
6-8	72	112	70	109	72	112	72	104
9-11	64	104	66	100	70	114	68	102
12-14	60	96	52	96	64	112	64	100
15-17	56	96	54	86	62	106	64	104
18-20	60	96	52	84	64	104	62	102
21-24	60	96	50	88	64	108	64	100

In families with two children ages 6-11 or 12-17 years in the sample, the youngest child was selected for these analyses. Data on mother's age, race, pregnancy, birth control pill use, history of hypertension, and blood pressure medication use were obtained from the household interview. Mother's pulse rate, and a single blood pressure, taken at the beginning of the examination, height, and weight were measured at the examination center as described elsewhere (*3-5*).

Estimates for the U.S. population for many variables other than pulse rate have been published by the National Center for Health Statistics (NCHS) in the form of Series 11 reports (*5-9*). The plan of the analyses in this paper was as follows:

Data from locations 1 to 65 of the general examination sample were used (*3*). Age strata were formed so as to ensure adequate numbers of persons in each stratum and to enhance comparability with previous NCHS surveys and reports. Detailed descriptive statistics and measures of association were computed initially using unweighted data. Kendall's nonparametric rank correlation was used to assess the association of pulse rate with other variables except in the family analyses, which used Pearson correlation (*10*). Analysis of covariance was used to compute adjusted means for subjects within sex and race categories and to assess the statistical signficance of differences of means among groups (*11*).

Stepwise linear multiple regression analysis (SAS FORWARD) was used to develop models for predicting pulse rate for each sex-race group (*12*). Only variables with prespecified hypotheses or with statistically significant univariate correlation coefficients were eligible to enter the regression models. Following these preliminary analyses, preplanned hypotheses and major findings of the unweighted analyses were confirmed using techniques that incorporated sampling weights and design features of the survey (*13*). However, no appropriate weights were available for family units, so all family analyses were done unweighted. Population estimates for mean pulse rate and percentiles and statistical tests of weighted proportions were produced using the SESUDAAN and the PCTL procedures available through the Statistical Analysis System (SAS) (*14*). Associations of pulse rate with other variables were confirmed using the SURREGR procedure for linear regression models (*15*). In view of the large number of tests performed, $P < 0.01$ was required for statistical signficance.

Results

Age and sex. In each sex-race group, the weighted mean pulse rate fell with increasing age until 12-16 years; subsequently it changed little (figs. 1 and 2). The negative association with age was generally strongest before age 12. The pulse rate distribution was slightly skewed towards higher values. Table 1 gives the estimated 5th and 95th percentiles for the ambulatory U.S. civilian population ages 6-24 years. The double product of blood pressure and pulse rate, an index of cardiac oxygen consumption, changed little between ages 6 and 11 but rose slightly with increasing age after age 12. The mean and median pulse rates were higher in girls than in boys, especially after age 12. The sex difference increased with age due to a more rapid and prolonged decline of pulse rate with age in boys (figs. 1 and 2). In weighted analyses, the proportion of 6-11-year-old children with a pulse rate greater than 95 was generally greater in girls than in boys at each year of age and overall. For white boys the proportion was 0.26; white girls, 0.35; $z = 3.10$, $P < 0.01$; black boys 0.17, black girls 0.21, $z = 1.01$, not significant (NS). The proportion of 12-24 year-olds with a pulse rate greater than or equal to 90 was greater among females than males at each year of age and overall (0.27 versus 0.13, $z = 10.9$, $P < 0.001$). The double product of blood pressure and pulse rate was higher in females than males in both whites and blacks after age 9. However, the sex difference disappeared for whites ages 18-20 and 21-24.

Race. Blacks tended to have lower mean and median pulse rates than whites (fig. 1 and 2). The difference was greater for boys than for girls and for ages 12-24 than for ages 6-11. In weighted analyses, the proportion of 6-11-year-olds with pulse rates greater than or equal to 95 was higher in whites than in blacks at each year of age and overall (0.30 versus 0.19, $z = 5.14$, $P < 0.001$). The proportion of 12-24-year-olds with a pulse rate greater than or equal to 90 was greater in whites than in blacks at each year of age except for the 16-year-olds and overall (0.21 versus 0.11, $z = 4.2$, $P < 0.001$). The double product of blood pressure and pulse rate was consistently lower in black males than in other groups after age 9.

Demographics. In 6-11-year-olds, within single-year groups no consistent association of pulse with family income, poverty status, or parental education level was observed in any sex-race group. Neither sibship size nor birth order was associated with pulse rate. In 12-24-year-olds and in 15-17-year-olds, no consistent association of pulse rate with these variables was seen. Nor was pulse rate associated with family income, poverty status, parental education, or participant's education in 18-20-year-olds and 21-24-year-olds. Married males 18-20 and 21-24 tended to have slightly higher pulse rates than the never married males, but no difference was seen in females.

In the age groups mentioned previously, no consistent association of pulse rate was observed with region, size of place of residence, or urban versus rural residence with the exception of slightly higher pulse rates in white females ages 12-14 and 15-17 years in the South and slightly higher pulse rates in rural dwelling whites compared with urban whites among the 18-20 and 21-24-year-olds. Within 1-year age groups, the pulse rate of 6-11-year-olds tended to be slightly higher in the fall (October to December) in many of the sex-race groups. Pulse rate was consistently higher after noon than before noon in almost all age, sex, and race groups. The majority (81 percent) of examinations were performed between 0900 and 1700 hours, and all were between 0800 and 2200 hours. Rank correlations of pulse with hour of the day were significant in 9-11-year-olds. In 12-14 and 15-17-year-olds, the pulse rate tended to be slightly higher in winter (January to March) and fall than in other seasons, and mean pulse rate was consistently slightly higher after noon than before noon, although the relationships were generally not significant within subgroups. Similarly, in 18-20 and 21-24-year-olds pulse rate tended to be slightly higher in fall and winter than other seasons and consistently higher after noon than before noon, but again, the relationships were generally not statistically significant within subgroups.

Maturation. At ages 6-8, skeletal age was negatively correlated with pulse rate in girls. Birth weight was not associated with pulse rate. Within age groups 12-14 and 15-17, skeletal age was not consistently related to pulse rate. In girls ages 12-14, no consistent difference in pulse rate was seen between those who reported that their menstrual periods had started and those whose periods had not started.

Unweighted univariate correlations. Pulse rate was not significantly correlated with blood pressure at ages 6-8 but at ages 9-11 it was significantly correlated with both systolic and diastolic blood pressure but not with pulse pressure. At ages 12-14, pulse rate was significantly correlated with blood pressure in girls and white boys. At ages 15-17, pulse rate was significantly correlated with blood pressure only in whites. At ages 18-20 and 21-24, pulse rate was significantly correlated with blood pressure again only in whites. Pulse rate was not consistently related to pulse pressure.

Among all those 12 or older, no consistent difference in pulse rates between teetotalers and regular drinkers of alcohol was seen within age groups, nor was type or amount of beverage consumed related to pulse rate. In these age groups, persons reporting that they were very active compared with moderately active in nonrecreational activity and those who said that they got much compared with moderate exercise in recreation generally had slightly lower pulse rates. Few reported being sedentary in response to the two activity questions. These trends were generally less consistent at ages 18-24 than at 12-17 for each sex-race group. However, these associations were generally not statistically significant by rank correlation. No consistent association of mean pulse rate with a history of birth control pill use in the past 6 months or current use was seen within the 15- to 24-year age groups. Nor was a history of ever

Table 2. Stepwise regression analysis with resting pulse rate as the dependent variable in children ages 6–11 years

	6–8 years				9–11 years			
Sex and race	*Age (months) b =*	*Other variables*	*b =*	*R^2*	*Age (months) b =*	*Other variables*	*b =*	*R^2*
Model A (see text)[1]								
White boys	−0.29	Age × hour of day	0.01	0.06	−0.28	Age × SBP	0.61	0.11
						Hour of day	0.00	
Black boys	NS	...		...	−0.41	Age × SBP	0.00	0.09
White girls	3.46 NS	Height	0.41	0.09	−2.6	SBP	0.19	0.08
		SBP	0.18			Hour of day	0.53	
		Age × temperature	0.03			Age × temperature	0.03	
Black girls	NS	...		...	−0.09 NS	Region × season	5.7	0.08
Model B-bone age instead of height[1]								
White boys	−0.20	...		0.03	−0.25	Age × SBP	0.00	0.11
						Hour	0.61	
Black boys	NS	...		...	−0.42	Age × SBP	0.00	0.09
White girls	−4.16	Age × temperature	0.04	0.08	−0.01 NS	SBP	0.19	0.09
		SBP	0.15			Temperature	3.4	
		South Region	3.53			Hour of day	0.52	
Black girls	NS	...		...	0.12 NS	Region × season	5.77	0.09

[1] Variables meeting the following criteria are included in the analysis; significance level for entry was 0.5; increment in $R^2 > 0.009$; significance of the regression coefficient *b* was $P < 0.01$. Variables are listed in order of entry; *b* and R^2 are listed with all variables in the model.

NOTE: NS = not significant; SBP = systolic blood pressure.

having been pregnant or the number of pregnancies or births related to pulse rate.

Multivariate analyses. The hypothesis of no racial difference in pulse rate was tested using an unweighted analysis of covariance. The mean pulse rates of blacks and whites were compared after adjusting for age in months, height, body temperature, region of residence, poverty index, season, hour of the day, and systolic blood pressure. Among 6–8 and 9–11-year-olds, blacks had consistently significantly lower pulse rates than whites in these analyses ($P < 0.01$) except for girls ages 6–8. In males ages 12–24, blacks had significantly lower adjusted pulse rates than whites ($P < 0.01$) within 3-year age groups. In females, adjusted pulse rates were consistently lower in blacks than in whites, but the differences were significant only at ages 12–14 and 21–24 ($P < 0.01$).

The hypothesis of no sex difference in pulse rate was tested using an unweighted analysis of covariance by comparing means of pulse rates of males and females after adjusting for age in months, height, body temperature, region, poverty index, season, hour of the day, and systolic blood pressure. Pulse rate was significantly higher in girls than in boys at ages 9–11 in whites and blacks ($P < 0.001$). At ages 12–24 among both whites and blacks, females had significantly higher adjusted pulse rates ($P < 0.01$) within 3-year age groups. No significant interactions with sex were seen except for a sex by region interaction in white females ages 12–14.

Unweighted forward stepwise linear regression was performed with pulse rate as the dependent variable and age in months, South Region, poverty index, fall and winter season, hour of the day, height, sum of skinfolds, body temperature, and systolic blood pressure and the interactions of these variables with age in months as independent variables. Age was forced to enter each model. Other variables were considered significant predictors if they met the 0.5 criterion for entry, added ≥ 0.009 to R^2, and had regression coefficients significant at the $P < 0.01$ level. Significant independent predictors are shown in table 2. For each age-sex-race group in this table and in table 3, the variable names, their regression coefficients, and the R^2 are given for the model with all significant variables and age entered.

Less than 12 percent of the variance in pulse rate was explained, and variables in the models varied greatly by subgroup, suggesting that the important determinants of pulse rate were not among the variables measured. No variable was consistently related to pulse rate across all subgroups among 6–11-year-olds.

The same regression analyses were repeated among 12-24-year-olds. Significant independent predictors within subgroups are shown in table 3. Less than 17 percent of the overall variance was explained. Addition of the other less significant variables not included in table 3 generally added only a few percentages to R^2, which was generally less than 17 percent, even with all variables meeting the 0.5 entry criterion in the model. Body temperature and systolic blood pressure were most consistently related to pulse rate across subgroups except for black males.

A series of simple and multiple linear regression analyses taking account of sample weights and design was performed with pulse rate as the dependent variable and age in months, female sex, white race, height, South Region, fall and winter season, poverty index, hour of the day, sum of skinfolds, systolic blood pressure, body temperature, and the interactions of these variables with age as independent variables. At ages 6-11 years, height or age was the variable with the strongest and most consistent significant independent associations with pulse rate in the entire sample. Sex- and race-specific analyses were not done because of the small sample size of black subgroups which did not meet requirements for the SURREGR program. Trends toward higher pulse rates in whites than blacks and in girls than in boys did not achieve statistical significance in the weighted multiple regression analysis.

These analyses were repeated for 12-24-year-olds. Positive independent associations of female sex, systolic blood pressure, and body temperature and negative independent associations of height with pulse rate were confirmed. Race was not consistently significantly related to pulse rate across various models in the entire sample. However, in 12-17 and 18-24-year-old males, white race, systolic blood pressure, and body temperature were positively associated with pulse rate ($P < 0.01$) in a reduced model controlling age, height, and age times height. The same reduced model in females yielded significant associations for systolic blood pressure and temperature in 12-17-year-olds and for race and systolic blood pressure in 18-24-year-olds. Exclusion of outliers on variables in the model, persons on blood pressure or heart medication, and persons with the very highest sample weights (greater than 32,767) did not alter the results of this analysis.

Unweighted multiple linear regression analyses were performed with blood pressure as the dependent variable and pulse rate and potential confounders as independent variables to assess the independence of the association of pulse rate with blood pressure. With age in months controlled, pulse rate was not significantly associated with systolic blood pressure at ages 6-8 except in white girls, but rate was significantly associated with systolic blood pressure at ages 9-11 except among black girls. The same pattern held for diastolic blood pressure except that there was no significant association in black boys at ages 9-11. If height instead of age was controlled, the results were also the same when age, body temperature, and hour of the day were controlled. In regression models, for all sex-race groups combined, taking account of sample weights and design, the significant independent positive association of pulse rate with systolic and diastolic blood pressure in the 9-11-year-old subgroup was confirmed.

In 12-24-year-olds, similar analyses by 3-year age groups, sex, and race indicated that pulse rate was significantly positively correlated with systolic blood pressure independent of age, body temperature, and sum of skinfolds in white males and white females. Associations were weaker and generally not significant in blacks. Independent associations of pulse rates with diastolic blood pressure were weaker and not consistently significant in these unweighted analyses. In regression models for all sex-race groups combined, taking account of sample weights and design, the independent positive association of pulse rate with systolic blood pressure ($P < .001$) and diastolic blood pressure ($P < .001$) in 12-24-year-olds was confirmed.

Pulse rate was available for 602 white and 166 black children ages 6-11 and 553 white and 150 black children ages 12-17 whose mothers were also examined in the survey. Table 4 shows unweighted mother-child correlation coefficients for white children. Correlations for height were consistently positive and statistically significant at most ages. The child's pulse was not significantly correlated with the mother's pulse or blood pressure (not shown) in age-specific analyses. Mother-child correlation coefficients were generally positive for the other variables shown, but they failed to attain statistical significance in most cases even though most age-sex groups contained 30-50 children. The number of black children was small, making age-specific analyses difficult. Within 1- or 2-year age groups, coefficients for blacks were generally positive but not statistically significant. For ages 6-11 and 12-17 combined, mother-child correlations for pulse were not significant in blacks although three of four correlations for height were significant. Results were similar when mothers who were preg-

Table 3. Stepwise regression[1] with resting pulse as the dependent variable in children and young adults ages 12–24 years

	White			Black		
Sex and age	*Variable*	*Regression coefficient b =*	R^2	*Variable*	*Regression coefficient b =*	R^2
Males						
12–14 years	Temperature	4.97	0.08	Age (months)	−0.42	0.11
	Sum of skinfolds	0.14				
15–17 years	Temperature	5.49	0.07	Not significant[2]		
	Systolic blood pressure	0.15				
18–20 years	Temperature	5.18	0.11	Not significant		
	Systolic blood pressure	0.19				
21–24 years	Systolic blood pressure	0.23	0.11	Not significant		
	South Region	4.61				
	Temperature	3.40				
Females						
12–14 years	Systolic blood pressure	0.23	0.05	Temperature	6.17	0.16
				Systolic blood pressure	0.26	
15–17 years	Systolic blood pressure	0.23	0.10	Temperature	7.40	0.08
	Region × season	6.34				
	Temperature	4.00				
18–20 years	Systolic blood pressure	0.17	0.03	Not significant		
21–24 years	Systolic blood pressure	0.23	0.05	Systolic blood pressure	0.14	0.04

[1] Variables meeting the following criteria are included in the table: significance level for entry 0.5; increment in R^2 more than 0.009; significance of regression coefficient b $P < 0.01$. Variables are listed in order of entry; b and R^2 are with all listed variables in the model.

[2] Although no variable met all the criteria, the overall model was significant after entry of temperature, height, poverty index, and systolic blood pressure.

nant or on birth control bills or blood pressure medication were excluded.

Adjusted mean pulse rates of the children of mothers with and without a history of high blood pressure were compared. A history of high blood pressure in the mother was associated with a lower age-adjusted mean pulse rate in the 6–11-year-olds, among white girls [85.1, standard error (SE) 2.1 versus 90.2, SE 0.7, P = 0.024] but not among white boys (89.4, SE 2.2 versus 86.1, SE 0.8, P = 0.155). No significant differences were seen among blacks. Hypertension on examination (SBP > 140 mmHg or DBP > 90 mmHg or on BP medication) in the mother was associated with higher age-adjusted mean pulse in white boys (89.5, SE 1.7, versus 85.7, SE 0.8, P = 0.046) but not in white girls (88.3, SE 1.6 versus 90.0, SE 0.7, P = 0.330), not inconsistent with the results for history of high blood pressure. No significant differences were seen among blacks. The groups with a history of high blood pressure or with hypertension on examination were not mutually exclusive. These results were essentially unchanged after adjusting for child's weight, height, and mother's age in addition to child's age in months. The association of mother's history of high blood pressure with child's pulse adjusted for the variables just mentioned was no longer significant in white girls after girls with mothers who were pregnant or on birth control pills were excluded, though the trend remained. This association was significant in girls whose mothers had more than three live births but not in those with fewer live births.

At ages 12–17 neither the mother's history of high blood pressure nor hypertension status at examination was significantly associated with age-adjusted child's pulse rate. However, a trend was seen towards lower rates in black girls if the mothers had a history of high blood pressure (75.6, SE 2.5 versus 81.9, SE 2.0, P = 0.057). This difference persisted after adjusting for child's weight, height, and mother's age in addition to child's age if mothers or daughters who were pregnant or on birth control pills were excluded (74.6, SE 2.9 versus 82.7, SE 2.4, P = 0.039). The number of girls in this subgroup was too small to permit examination for girls whose mothers had more than three versus three or fewer live births.

Discussion

In a national sample of children and young adults, correlates of resting pulse rate were examined. At ages 6–11, pulse rate was inversely related to age or height. Trends toward a higher pulse rate in females than males and in whites than blacks did not remain statistically significant when sample weight, design, and multiple possible confounders were taken into account. Associations with other variables at this age were weak and inconsistent.

At ages 12–17 and 18–24, age was no longer significantly correlated with pulse rate. Females had significantly higher pulse rates than males. Black males had significantly lower pulse rates than white males. In addition, blood pressure and body temperature showed consistent positive associations with pulse rate in whites. Relatively little of the overall variation in pulse rate was explained by measured variables. Mother-child age-specific correlation coefficients for pulse and blood pressure were generally positive, but they were not statistically significant.

Mechanisms. The rapid changes in heart rate and other cardiovascular variables in childhood are related chiefly to growth and development, perhaps explaining the low percentage of variation explained at ages 6–11. Environmental factors may become increasingly important determinants of cardiovascular variables during the transition from adolescence to adulthood (*16, 17*). The independent sex and race associations seen in these analyses together with significantly high heritability estimates for heart rate previously reported suggest some degree of genetic determination (*18*). The estimated independent effect of temperature on pulse rate (1 to 5 beats per minute per degree Fahrenheit for ages 12–24) in these analyses was much less than the increase of 11 beats per minute per degree given in the literature (*19*). However, within-individual estimates might differ from these cross-sectional analyses. Contrary to suggestions in the literature (*19*), body temperature did not explain the sex difference in pulse rate observed in adolescents and young adults.

The lack of positive significant correlations of pulse rate and blood pressure in blacks may be of importance in view of the weak but consistent significant positive correlations in whites and the well-known racial differences in blood pressure among adults. Similar findings were reported from the Bogalusa heart study (*20*). Perhaps heart rate is a less important determinant of blood pressure in blacks because of volume expansion or increased peripheral resistance, as discussed elsewhere (*21*). Racial differences in the sympathetic nervous system development of children between ages 6 and 24, as indicated by lower heart rates in blacks than whites, could indicate racial differences in the tropic influence of the sympathetic nerves on blood vessel development in fetal life and in early childhood that might influence the susceptibility to hypertension in later life (*22*). A possible role of atrial natriuretic peptide (atriopeptin, atrial natriuretic factor) might be examined in explaining racial differences in cardiovascular function and disease (*23*). Further research is needed since an elevated pulse rate has been established as a risk factor for hypertension in both whites and blacks (*2, 24, 25*), and it is modifiable by school-based interventions (*26*).

Comparisons with previous reports. For children ages 6–11 in HANES I, sitting mean pulse rates are similar but more variable than supine pulse rates reported for the National Health Examination Survey (HES) Cycle II of 1963 to 1965 (*27*). This is probably due to the threefold larger sample of the earlier survey. Smaller sample size, in addition to the use of sample weights and design in the analysis, may account for the failure to detect statistically significant sex and race effects in the HANES I weighted regression analyses in contrast to HES II. However, trends toward higher pulse rate in girls and in whites are in the same direction in both HANES and HES. Results for unweighted analyses were similar. Age trends were similar in both surveys. A positive association of pulse rate with blood pressure was also reported in both HES and HANES (*27*).

Distributions of supine resting apical heart rate and double product in the Bogalusa Heart Study were similar to those of HANES for 6–17-year-old children (*20*). Age, sex, and race trends agreed as well. Stronger positive associations of heart rate with blood pressure in whites compared with blacks were reported, similar to those observed in HANES (*20*). The positive associations of skinfold thickness with heart rate reported in Bogalusa males were found in HANES analyses only for white males ages 12–14 years. Among 18–20 and 21–24-year-olds, major effects of variables related to socioeconomic status and lifestyle on pulse rate were not found in HANES. Such lifestyle effects were reported from Bogalusa for blood pressure and blood lipid levels, but no analyses of heart rate with these variables were published (*16*).

Standing pulse rates in the Health Examination Survey Cycle III of 1966–70 were 5 to 15 beats per minute higher than sitting pulse rates in HANES for 12–17-year-olds (*28*). The difference was greater in females than males and in whites than blacks. Whites had significantly higher pulse rates than blacks, and girls had significantly higher pulse rates than boys in the earlier survey. Black males had the lowest double product values in both surveys. As in

Table 4. Mother-child correlation coefficients for white children, First National Health and Nutrition Examination Survey, 1971-73

Age (years)	Pulse	SBP	DBP	CHOL	Weight	Height	BMI
				Boys			
6	0.17	0.25	0.20	-0.05	0.19	[1]0.39	0.07
7	0.00	[1]0.36	0.17	-0.03	-0.08	[1]0.31	-0.11
8	0.11	0.08	0.21	[1]0.37	0.26	[1]0.36	[1]0.37
9	0.06	0.15	0.16	0.31	0.09	0.26	0.13
10	[1]0.32	0.22	0.18	0.21	0.14	[1]0.29	0.15
11	[1]0.28	[1]0.35	0.27	[1]0.41	[1]0.43	[1]0.41	[1]0.38
12	0.08	[1]0.32	[1]0.35	-0.04	[1]0.33	[1]0.31	[1]0.29
13	0.08	0.18	[1]0.41	0.16	0.08	0.13	0.02
14	-0.07	[1]0.44	-0.04	[1]0.46	0.10	[1]0.53	0.24
15	0.03	[1]0.35	[1]0.53	0.26	0.09	0.18	0.02
16	-0.07	0.15	-0.03	0.27	0.20	[1]0.56	0.03
17	[1]0.49	0.27	0.13	-0.26	0.12	[1]0.38	0.05
6-11	[1]0.14	[1]0.27	[1]0.20	[1]0.23	[1]0.19	[1]0.19	[1]0.18
12-17	0.09	[1]0.27	[1]0.22	[1]0.17	0.11	[1]0.23	[1]0.12
				Girls			
6	0.03	-0.12	-0.19	0.17	0.21	0.21	0.10
7	0.25	0.12	0.01	0.08	0.16	[1]0.48	0.02
8	[1]0.33	-0.00	0.13	[1]0.38	0.22	[1]0.44	0.07
9	0.18	-0.09	0.02	[1]0.42	0.22	[1]0.50	0.19
10	0.06	0.15	0.25	0.14	0.05	[1]0.30	0.02
11	-0.04	0.06	0.14	[1]0.31	0.10	[1]0.34	0.28
12	-0.04	0.17	0.26	[1]0.37	[1]0.32	0.16	[1]0.41
13	-0.22	0.22	0.18	[1]0.56	[1]0.55	[1]0.32	[1]0.53
14	0.15	-0.02	0.07	[1]0.45	[1]0.49	[1]0.61	[1]0.48
15	0.31	-0.07	0.05	-0.15	0.09	[1]0.50	0.03
16	-0.20	0.10	[1]0.34	0.07	[1]0.42	[1]0.69	0.27
17	0.10	0.25	0.12	[1]0.45	0.18	0.30	0.32
6-11	[1]0.13	0.04	0.09	[1]0.25	[1]0.22	[1]0.20	[1]0.19
12-17	0.02	[1]0.12	[1]0.17	[1]0.33	[1]0.36	[1]0.41	[1]0.37

[1] $P < 0.05$. NOTE: SBP = systolic blood pressure; DBP = diastolic blood pressure; CHOL = serum cholesterol; BMI = body mass index.

HANES, systolic blood pressure and body temperature were significant independent correlates of pulse rate in HES Cycle III (*28*). As for HES Cycle II, the findings of significant race differences in pulse rate for both sexes was probably due to the much larger sample size and the type of analyses (*28*). Again, the results for unweighted analyses were similar. In HES Cycle I from 1960 to 1962, heart rate was significantly correlated with blood pressure in all groups except black males ages 18-34 and with indices of obesity in white males ages 18-34 (*29*). Other studies confirm this correlation in adolescents in Nigeria and black and white medical students (*30,31*).

In a Pittsburgh study of children ages 0-60 months, unlike HANES I, significant negative mother-child correlations of blood pressure and, like HANES I, inconsistent positive mother-child correlations of heart rate were found, suggesting genetic control of heart rate and low heart rate as a possible risk factor for hypertension in later life (*32, 33*). Findings for children ages 1-5 years in HANES I were similar to those for children ages 6-11 (*34*). Negative findings were reported regarding a history of maternal hypertension in 1-5-year-olds in Pittsburgh and HANES I. The HANES I finding regarding maternal hypertension on examination in boys (lower pulse rates) but not girls (higher pulse rates) at ages 1-5 was inconsistent with findings for ages 6-17. Such discrepancies might arise from differences in the samples, ages, methods (Pittsburgh versus HANES), and reporting or by chance.

Limitations of the present study include possible bias arising from survey nonresponse and from missing values for some variables (for example, blood pressure at age 6); and confounding by variables not measured such as room temperature or emotional state of participants. Several special studies of HANES data have indicated little bias due to nonresponse (*13*). Adequate reliability has been demonstrated for resting pulse rate in children and adolescents (*20*). The relatively large sample size provided good statistical power for the overall sample and for whites, and the conservative criteria for statistical significance reduced the possibility of chance findings attaining significance despite a large number of tests. However, statistical power was limited for blacks and for subgroups in the family analyses. Although some of the variation in associations of variables such as blood pressure with pulse rate across age-sex-race groups may be due to chance, some patterns probably have biologic significance (for example, appearance of much stronger independent associations of blood pressure and pulse rate at ages 12–24 than at ages 6–11 in white males). The representativeness of the sample and the use of sample weights provide wide generalizability of the results to U.S. black and white children and young adults of the same ages. However, the results of family analyses must be interpreted and generalized with caution due to limitations of the data that have just been detailed.

Future research should include longitudinal studies of resting pulse rate, blood pressure, and noninvasive measures of circulatory function in white and black children followed to adulthood. In such studies the resting pulse rate in childhood and adolescence should be assessed as a risk factor for future elevated blood pressure within race-sex groups and the mechanisms of such an association evaluated. Measurement of indicators of sympathetic nervous activity, plasma volume, and levels of hormones with volume-regulatory activity might help elucidate the mechanisms of race and gender differences in pulse rate and blood pressure.

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A Study Guided by the Health Belief Model of the Predictors of Breast Cancer Screening of Women Ages 40 and Older

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Synopsis ....

In late 1987, a total of 852 Rhode Island women ages 40 and older were interviewed by telephone (78 percent response rate) to measure their use of breast cancer screening and to investigate potential predictors of use. Predictors included the women's socioeconomic status, use of medical care, a provider's reported recommendations for screening, and the women's health beliefs about breast cancer and mammography.

The Health Belief Model guided the construction of the interview questions and data analysis. Logistic regression was used to identify leading independent predictors of breast cancer screening according to contemporary recommendations: reporting that a medical provider had ever recommended a screening mammogram (odds ratio [OR] = 18.77), having received gynecological care in the previous year (OR = 4.92), having a regular source of gynecological care (OR = 2.63), having ever had a diagnostic mammogram (OR = 2.32), and perceiving mammography as safe enough to have annually (OR = 1.93).