PERCEIVED STRESS AND BLOOD PRESSURE IN EARLY ADOLESCENT CHILDREN[1]

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Abstract:

The objective of this investigation was to determine the individual contributions of perceived daily, major and total stressors to blood pressure in early adolescent children. Toward this goal, cardiovascular risk factors were assessed in 74 6th- grade students. Height and body weight, measured in standard fashion, were used to calculate body mass index (BMI). Waist and hip circumferences and triceps and calf skinfolds were taken to determine the distribution and percentage of body fat, respectively. Seated resting blood pressure was obtained using a mercury sphygmomanometer The dietary sodium-to-potassium ratio was calculated from a food intake questionnaire, Family history of hypertension was self-reported by participant's parents, and physical activity and perceived stress levels were determined by questionnaire. When added to the hierarchical regression models, the perceived stress variables did not significantly predict any additional variance in systolic or diastolic blood pressure in this early adolescent sample. Additionally, bivariate correlations between the stress variables and blood pressure were nonsignificant. The nonpsychological hypertension risk factors accounted for 25%-35% of the total variance in systolic and diastolic blood pressure. Further, regression analyses revealed that with the exception of BMI and the sodium-to-potassium ratio, no other risk factors were independent predictors of systolic or diastolic blood pressure. Further identification and understanding of environmental precursors of childhood hypertension is recommended.

Article:

INTRODUCTION

Hypertension has been identified as the most potent and prevalent antecedent of cardiovascular disease (1,2). The 1988- 1991 National Health and Nutrition Examination Survey III indicates that as many as 50 million Americans aged 6 and older suffer from high blood pressure (3). Hypertension has pediatric roots, and childhood blood pressure levels have been shown to track into adulthood (4). Hence, identifying and understanding precursors of hypertension that may be detectable during the pediatric years is essential.

While it has long been assumed that frequent or prolonged exposure to stressful psychological and environmental events promotes the development of essential hypertension in adults, it has proven difficult for researchers to establish the role that stress may play as an independent contributor in the development of hypertension (5). There is an abundance of research documenting that aversive stimuli cause temporary elevations in blood pressure in both children and adults (6-8). This response, however, diminishes once the stress-causing agent is terminated or removed. Animal studies have produced the strongest evidence for a stress-hypertension link. Mice exposed to social disruption, for instance, develop sustained hypertension due to chronic activation of the sympathetic nervous system (9,10). Human studies focusing on the relationship between stress and blood pressure have also shown that individuals in high-stress occupations such as air traffic controllers, urban bus drivers, and police officers experience high rates of hypertension (11-13).

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Research examining the stress-hypertension link has been characterized by methodological inadequacies such as the absence of control groups and appropriate controls for confounding variables, the use of measures which lack validity and reliability, and the absence of a uniform definition of stress (14-16). Another common limitation in past studies on children's stress has been the reliance on parental reports of children's stress levels as compared to using the child's own perception. In considering this latter point, researchers who have attempted to assess psychological stress in children have tended to employ scales designed for use with adults (16).

Clearly defining stress is an important requirement for examining the relationship between stress and blood pressure. Lazarus (17) proposed that stress is the internal state of an individual who perceives threats to his or her physical or psychic well-being. As such, an appropriate measure of stress should include some assessment of the individual's perception of each event or situation. Additionally, when attempting to study stress and its effects on health, there has been controversy over whether to focus on major life events or smaller, more chronic events. Studies of major life events have only been able to account for a small portion of the variance in the development of physical and psychological symptoms (18). In contrast, daily hassles which are stressors experienced in everyday life, have been found to be a better measure of the stress experienced by adults (19). In support of this assertion, DeLongis et al. (19) noted that daily hassles accounted for a greater percentage of the variance in overall health status. It has also been postulated that major events and daily hassles may operate interactively (18).

The purpose of this study was to determine if children's perceived daily, major, or total stress levels were significant individual predictors of blood pressure. To account for the potential influence of nonstress factors on blood pressure, a number of pertinent variables including sex, percent body fat, body mass index (BMI), waist-to-hip ratio (WHR), parental history of hypertension, dietary sodium-to-potassium ratio, and physical activity levels were controlled statistically. Because both daily hassles and major stressors may potentially contribute to an individual's overall stress level, a measure designed for children that includes both types of stressors was selected for use in this investigation. Further, given the key role of perception in Lazarus' stress model, this measure also evaluated the child's own perception of the stressfulness of these daily and major events.

METHODS

Participants

Voluntary participation in this study was sought from 6th- grade students in an urban public middle school. Written parental consent was obtained and complete data were collected on all of the 74 students in the morning physical education classes. Based on a health history form completed by each child's parent or guardian, it was determined that all participants were free of an organic basis for hypertension and had no prior history of a diagnosis of high blood pressure. Five students were excluded from the sample because they were on medication known to influence blood pressure levels. The remaining sample of 69 participants was 43% male with a mean age of 11.7 ± 0.7 years. Analysis of ethnic background revealed that the sample was 54% African—American, 35% Caucasian, 6% Asian, and 5% Native American.

Physical Measures

Body Mass and Height: A single measure of body weight was taken (without socks and shoes) to the nearest 0.1 pound using an electronic scale (Seca Alpha, Model 770). Using an anthropometer, a single measure of height was taken to the nearest 0.1 cm. During the height measurement, participants stood barefoot on a flat surface with heels together and body mass distributed evenly on both feet. The head was positioned so the line of vision was approximately horizontal and the sagittal plane of the head was vertical. Body mass and height measurements were used to calculate body mass index, BMI = [weight (kg)/height $(m)^2$].

Waist-to-Hip Ratio: Waist and hip circumference were taken with a Gulick II Measuring Tape (Model 67020) while participants were in an upright standing position. The tape has a tensioning device which was calibrated to ensure that each measurement was taken with the same amount (4 oz.) of tape tension. A single circumference value (taken to the nearest 0.1 cm) was obtained at each site. Waist girth was taken at the level of the umbilicus and hip girth was measured at the maximum posterior extension between the buttocks and the iliac crest (20). As a practical matter, the waist measurement was taken directly on the skin, whereas the hip measurement was made over the student's undergarments. The waist measurement was divided by the hip measurement to calculate the waist-to-hip ratio.

Triceps and Calf Skinfolds: A single investigator measured triceps and medial calf skinfold thicknesses to the nearest millimeter using a Harpendon skinfold caliper. Prior to testing, the technician was validated against an American College of Sports Medicine (ACSM) Exercise Test Technologist and checked for within-tester reliability. Intraclass correlation coefficient determined for each pairing (e.g. technician A and expert, technician A and technician A) revealed high correlations *(r ?* 0.99).

Both skinfold measurements were obtained following standardized procedures (21). Measurements were taken twice at each site, in sequential order, and averaged. If the two initial readings did not agree within one millimeter, a third reading was obtained. Prediction equations of percent fat from triceps and calf skinfolds derived by Slaughter, Lohman, Boileau, and Horswill (22) were used to estimate percent body fat.

Resting Blood Pressure: After a minimum of 5 minutes of seated rest, blood pressure was obtained with a mercury sphygmomanometer according to the recommendations of the National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents (23). Two resting blood pressure readings were taken by the same technician on each participant with approximately 2 minutes separating each reading. Values were averaged to produce one resting blood pressure measurement for each student.

Prior to data collection, two blood pressure technicians were validated against an ACSM-certified Program Director and checked for reliability against themselves and the other technician. Intra- class correlation coefficient determined for each pairing (e.g. technician and expert, technician A and technician A, technician A and technician B, technician B and technician B) revealed high correlations ($r \geq 0.85$).

Questionnaires

Dietary Analysis: Parents and children jointly completed a food intake questionnaire which was evaluated with the Nutritionist IV: Diet Analysis and Nutritional Evaluation computer program (N-squared Computing, Silverton, Oregon). The questionnaire contains 141 different foods and general food categories, each with a specified serving size, and has previously been used in a study of blood pressure and diet in a racially-mixed sample (24). Parents were instructed to record how many servings, if any, the child consumed of each item in a typical week. The questionnaires were analyzed to determine each child's dietary sodium and potassium intake (mg per day). These data were used to derive the sodium-topotassium ratio.

Accurately measuring an individual's usual intake of nutrients is a difficult task. Food frequency questionnaires are useful in estimating weekly eating patterns, but have more limited ability in specifically quantifying an individual's dietary composition. In addition, parents may not always be aware of what children consume when they are away from home. Given these concerns, several steps were taken in order to help ensure the accuracy of the dietary records. First, parents and children jointly completed the questionnaire. Moreover, illustrations of typical serving sizes for the meat products were included in the questionnaire. The telephone number of a registered dietician was also included in all packets in the event that parents or children had any questions regarding the completion of the questionnaire.

Physical Activity: The Weekly Activity Checklist (25) was employed to measure physical activity. This checklist contains 20 activities commonly performed by children. Students were asked to report which activities they continuously engaged in for at least 15 minutes during the last week. Based on instructions provided by the authors of the Weekly Activity Checklist, participants were asked to report only those activities that were performed outside of school. The checklist was scored by multiplying the frequency of each activity by its metabolic equivalent score and then summing the products. Test—retest reliability and validity for the checklist have been supplied by the authors (25).

Family History: The Coronary Risk Profile (26) was used to gather information regarding coronary heart disease, stroke, high blood pressure, diabetes, kidney disease, and cigarette smoking. An additional column was added to the form so that age of onset could be specified. Students were given one point for each parent with high blood pressure occurring before the age of 55; therefore, students with no parental history of hypertension received a score of zero, students having one parent with hypertension received a score of one, and students with two parents with hypertension received a score of two.

Perceived Stress: The junior high school version of the Adolescent Perceived Events Scale (APES) was used to quantify daily, major, and total stressors (27). The scale contains a list of 164 events representative of those stressors experienced in early adolescence. Students were asked to indicate whether or not each event had occurred in the 3 months preceding the study and to note the perceived desirability of each event by selecting a rating on a Likert scale varying from —4 *(extremely undesirable)* to +4 *(extremely desirable).* The scale was scored by calculating the total weighted negative event scores for daily, major, and total stress by summing the desirability scores of each event rated negatively (negative desirability ratings ranged from —1 to —4). Ratings were summed separately for daily and major events according to classifications provided by the authors of the scale, resulting in three scores: a daily stress score, a major stress score, and a total stress score which was the sum of the daily and major scores. The 2-week test—retest reliability of the scale for the number of events reported and the weighted negative events is 0.85 and 0.86, respectively (27).

Because the APES provides a list of life events generated specifically by early adolescents, it is an improvement over previous scales and offers researchers an opportunity to partial out the effects of daily stress and major stress on blood pressure. The APES also provides a quantitative indication of the level of stress experienced by each child that is derived specifically from the child's own perception of the events occurring in his or her life. As noted earlier, these are important components to adequately assess and define stress.

Timetable and Logistics of Data Collection

Approximately 4 weeks prior to data collection, packets containing an information letter and an informed consent form were sent home to parents by the child's physical education teacher. Health history and the food intake questionnaires were mailed to those parents who returned signed consent forms. Phone calls were made to several parents to address small problems or inconsistencies detected on their completed questionnaires.

Data were collected at the school over a 2-week period. Each week, two classes were assessed during regularly scheduled physical education classes by a team of investigators. On the first day of each week, demographic data were collected and the APES was administered. Physical measurements, including body mass, height, waist and hip circumferences, and skinfolds were completed on the second day. A station was set up for each of the measurements and students rotated through the stations in small groups. On the final day of data collection, students completed the physical activity measure. Following this, resting blood pressure was measured as described earlier.

Statistical Analysis

Means and standard deviations were derived for all study variables. Bivariate correlations were calculated to quantify interrelationships among hypertension risk factors and resting systolic and diastolic blood pressure. Six separate hierarchical regression analyses were performed to determine if any of the three separate stress scores (daily, major, or total stress) predicted a significant portion of the variance in systolic and diastolic blood pressure. To account for the effect of known hypertension risk factors (e.g. body mass index, percent body fat, family history of hypertension, physical activity, sodium-to-potassium ratio, and waist-to-hip

TABLE 1
Participant Characteristics and Control Variables Measured in Males and Females ($N = 69$)

Variable	*M*	*SD*	Range
Age (yr)	11.7	0.7	11–13
Height (cm)	154.9	8.8	127.7–177.6
Body mass (kg)	54.7	17.3	25.5–107.6
Body mass index (kg/m^2)	22.4	5.8	15.42–41.1
Percent body fat	25.6	11.1	8.9–53.3
Waist-to-hip ratio	0.82	0.07	0.70–1.04
Physical activity	103.9	83	10–326
Sodium-to-potassium ratio	0.96	0.22	0.52–1.45

ratio), these control variables were entered on the first step of the equation. Daily stress, major stress, or total stress was entered on the second step to examine whether the stress variable added significantly to the predictive value of the model. As one-way analyses of variance revealed no significant differences among races on blood pressure or perceived stress, race was not entered into the regression models. The level of statistical significance was established at $p < .05$.

RESULTS

The means and standard deviations for each variable are displayed in Table 1. A parental history of self-reported hypertension (not included in Table 1) was present in 11 of the participants. None of the participants had two parents with self-reported hypertension. Additionally, the individual means by sex are provided for blood pressure and the perceived stress variables in Table 2. Based on blood pressure nomograms for children and adolescents in the United States (28), 13% of the females exhibited diastolic and/or systolic blood pressure levels above the 95t^{h} percentile for age, sex, and height. Of the male participants, 10% and 38% exhibited diastolic and systolic blood pressure levels, respectively, that fell above the 95th percentile for age, sex, and height. Using obesity standards of ≥32% body fat for females and ≥25% body fat for males (29), 33% of the females and 42% of the males were classified as obese.

Bivariate correlations among all hypertension risk factors, perceived stress, and mean systolic and diastolic blood pressures are presented in Table 3. Significant correlations were obtained between diastolic blood pressure and body mass index, percent body fat, sodium-to-potassium ratio, and waist-to-hip ratio. Systolic blood pressure was also correlated significantly with body mass index, percent body fat, and waist-to-hip ratio.

The control variables entered on the first step of the hierarchical regression equation accounted for 25% of the varianee in systolic blood pressure (see Table 4) and 35% of the variance in diastolic blood pressure (see Table 5). The only significant individual predictors of systolic and diastolic blood pressure were body mass index and the sodium-to-potassium ratio. Examination of the R^2 values and the standardized beta values (see Tables 4 and 5) revealed that neither daily, major, nor total stress added to the predictive value of the regression models. It should be noted that the distributions of the three stress scores were all positively skewed. To assure that the lack of a statistically significant relationship between blood pressure and stress was not a consequence of these nonnormal distributions, a log transformation of the stress scores was performed and the correlation and regression analyses were repeated. Use of the transformed stress scores did

TABLE 2
Perceived Stress Variables and Blood Pressure Comparisons Between 6th-Grade Males and Females

Variable	Overall ($N = 69$) *M*	Overall ($N = 69$) *SD*	Range	Males ($n = 30$) *M*	Males ($n = 30$) *SD*	Females ($n = 39$) *M*	Females ($n = 39$) *SD*
Daily stress	24.0	21.9	1–100	17.8	17.2	29.6*	24.3
Major stress	13.7	14.4	1–75	10.5	14.6	16.6	13.7
Total stress	37.6	34.6	3–161	28.3	30.5	46.2*	36.3
Mean diastolic blood pressure (mm Hg)	75	10	55–99	76	9	73	10
Mean systolic blood pressure (mm Hg)	114	14	79–150	119**	12	110	15

* $p < .05$ (difference between males and females).
** $p < .01$ (difference between males and females).

TABLE 3
Bivariate Pearson Product-Moment Correlations Among Hypertension Risk Factors, Perceived Stress, and Systolic and Diastolic Blood Pressure in 69 6th-Grade Males and Females

	BMI	PBF	WHR	FH	PA	SP	DS	MS	TS	MDBP
PBF	.79**	—								
WHR	.50**	.49**	—							
FH	.08	.13	.05	—						
PA	.00	−.04	.08	−.05	—					
SP	.05	.14	.08	.13	−.05	—				
DS	.11	.08	.05	.11	−.04	.05	—			
MS	−.05	.02	−.05	.05	−.06	−.14	.81**	—		
TS	.09	.06	.01	.09	−.05	−.09	.97**	.93**	—	
MDBP	.54**	.44**	.29**	.13	.00	.24*	−.02	−.03	−.03	—
MSBP	.46**	.34**	.36**	.05	.10	.06	−.06	−.06	−.07	.69**

Note: BMI = body mass index; PBF = percent body fat; WHR = waist-to-hip ratio; FH = family history; PA = physical activity; SP = sodium-to-potassium ratio; DS = daily stress; MS = major stress; TS = total stress; MDBP = mean diastolic blood pressure; MSBP = mean systolic blood pressure.
* $p < .05$.
** $p < .01$ (two-tailed).

not alter the findings. Consequently, results based on the original data have been reported.

DISCUSSION

With respect to physical features, participants in the current study were taller, heavier, and had a higher percent of body fat compared to the general age-matched population of children (30-32). The majority of the children exhibited systolic and diastolic blood pressure values within the normal range, although there was a noticeable incidence of elevated blood pressure values. This finding may be attributable to the marked presence of obesity and the fact that the children tended to fall in the upper percentiles for height and body mass (23), which, as noted by the Task Force on Blood Pressure Control in Children (24), tends to lead to higher blood pressure values.

In support of past research (33,34), significant positive correlations were observed between systolic and diastolic blood pressure and body mass index, percent body fat, and waist-to-hip ratio. Additionally, diastolic blood pressure was associated significantly with the sodium-to-potassium ratio. With respect to sex differences, female participants reported significantly higher levels of both daily and total perceived stress. Although not statistically significant, females also reported higher levels of stress due to major events. These findings extend results from previous studies indicating that females tend to score higher on measures of stressful life events (16,35) possibly because of a more external locus of control and/or a more negative self-concept (16). When considered within the context of the definition of stress advocated by Lazarus (17), these latter factors may render a female more likely to perceive a threat to her well-being and, in turn, experience higher levels of stress.

Mean scores for daily and major stress were also compared to two previous studies conducted by the first author of the APES. The mean scores (31.5 for daily stress and 14.7 for major stress) obtained when Compas, Howell, Phares, Williams, and Guinta (36) administered the APES to a group of children (mean age = 12.0 ± 1.0 years) are similar to the means in the current sample of children (see Table 2). Compas, Howell, Phares, Williams, and Ledoux (37) also conducted a study in which the APES was used with a group of children (mean age = 12.01 ± .97 years). The means were separated for males (25.8 for daily stress and 10.1 for major stress) and females (37.5 for daily stress and 16.16 for major stress) and again, as shown in Table 2, compare well with the results from the current sample. Across studies, the major stress scores are especially close, while the daily stress scores are consistently about 7 points lower in the present study than in the two comparison studies. This difference may lie in the fact that the list of events used on the APES was generated by children living in Vermont and both comparison studies drew samples from Vermont. In contrast, participants in the present study were drawn from an ethnically-mixed, but predominantly African-American population in North Carolina. Hence, between- study differences among daily stress scores may not necessarily mean that the children in the present study generally perceived less stress. Rather, the list of events on the APES may have been slightly more representative of the daily events occurring in the lives of children growing up in the northeast portion of Vermont, where the majority of families are Caucasian. Interestingly, the

TABLE 4

Results of Hierarchical Regression Analyses Examining the Influence of Daily, Major, and Total Stress on Systolic Blood Pressure in 6th-Grade Males and Females ($N = 69$)

Variable Entered	B	β	R^2	ΔR^2
Step 1[a]				
Body mass index	1.12	.46*		
Percent body fat	−.14	−.11		
Family history	.80	.02		
Physical activity	.02	.09		
Sodium-to-potassium ratio	2.78	.04		
Waist-to-hip ratio	35.59	.17	.25**	
Step 2[b]				
Daily stress	−.07	−.11	.26	.01
Major stress	−.06	−.07	.25	.00
Total stress	−.04	−.10	.26	.01

Note: Adjusted R^2 for Step 1 = .17.
[a] Control variables (established hypertension risk factors).
[b] Each stress variable was entered into a separate regression model with the same control variables on the first step.
* $p < .05$.
** $p < .01$.

TABLE 5

Results of Hierarchical Regression Analyses Examining the Influence of Daily, Major, and Total Stress on Diastolic Blood Pressure in 6th-Grade Males and Females ($N = 69$)

Variable Entered	B	β	R^2	ΔR^2
Step 1[a]				
Body mass index	.91	.55**		
Percent body fat	−.03	−.04		
Family history	1.64	.06		
Physical activity	.02	.02		
Sodium-to-potassium ratio	9.18	.22*		
Waist-to-hip ratio	1.74	.01	.35***	
Step 2[b]				
Daily stress	−.04	−.08	.35	.01
Major stress	−.02	−.03	.35	.00
Total stress	−.02	−.06	.35	.00

Note: Adjusted R^2 for Step 1 = .28.
[a] Control variables (established hypertension risk factors).
[b] Each stress variable was entered into a separate regression model with the same control variables on the first step.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

standard deviations associated with the stress means in the current investigation and in both of the Compas et al. studies (36,37) are consistently high. This phenomenon supports the contention that stress is dependent upon the perception of each individual and emphasizes the importance of individual appraisal in the assessment of life events.

Hierarchical regression analyses did not reveal a significant contribution of perceived stress to either systolic or diastolic blood pressure when variables known to influence blood pressure were accounted for statistically. Therefore, no deleterious effect of perceived negative life events on blood pressure was detected at the stage of childhood highlighted in the present study. It is conceivable that a longer period of time may be required for psychological disturbances to produce noticeable changes in resting blood pressure. Hence, future cross-sectional and longitudinal investigations examining a span of age groups would be useful in determining whether or not psychological stress exerts a more noticeable effect on blood pressure as children progress through adolescence and into adulthood.

By utilizing each child's perception of his or her stress level and attempting to control statistically for a large number of previously documented hypertension risk factors, this investigation strengthened methodological approaches featured in past research (14,16). In acknowledging that research on life stressors in children is in its infancy, the preliminary nature of the present study should be stressed. Clearly, hypertension is a complex phenomenon and the premise that a single precipitating factor can produce sustained hypertension is considered unlikely (38). Hierarchical regression analyses from this investigation, which revealed that nonstress related risk factors for hypertension accounted for only 25% to 35% of the total variance in systolic and diastolic blood pressure, confirm the multifaceted nature of adolescent blood pressure.

An examination of the limitations of the current study highlights several possibilities for enhancing research in this area. Clearly, the limited sample size employed in the current investigation restricts the generalizability of these findings and replication with larger samples is warranted. Further, the level of perceived stress in the current sample was comparable to other samples of children (36,37). It is possible that the relationship between perceived stress and physical health might be more apparent in groups of high-risk children featuring elevated or more extreme levels of perceived stress. In addition, the use of repeated blood pressure measurements and a more concise method of dietary analysis would strengthen the methodological framework of future studies.

The distinct roles that daily perceived stressors and major perceived stressors may play in influencing health status is also a fertile area for future study. Although the standardized beta weight for each stress variable was not statistically significant, the weights for daily stress were larger than those of major stress (see Tables 4 and 5). Hence, it is plausible, as suggested by DeLongis et al. (19), that more chronic stimuli, such as daily hassles, which elicit recurrent changes in blood pressure, may alter levels of blood pressure maintenance to a greater extent compared to major life events.

Additional factors not examined in the current study, such as socioeconomic status and stress coping styles, may also influence a child's perception of the events in his or her life and explain additional variance in childhood blood pressure (39-41). Past research has shown that the combination of a John Henry coping style and a low socioeconomic status is associated with elevated resting blood pressure values in African—American children (42). Further, the suppression of angry feelings has been linked to elevated blood pressure in adolescent males (43). Given the extensive number of physical, psychological, social, genetic, and environmental variables known to be associated with variations in blood pressure, it is unlikely that all pertinent aspects can be controlled in a single investigation. Nonetheless, future investigations should attempt to account for as many relevant factors to the population under investigation as is possible.

In conclusion, after established risk factors of hypertension were controlled statistically, perceived stress did not significantly predict any additional variance in systolic or diastolic blood pressure in 6th-grade students of diverse ethnic backgrounds. Given the widespread occurrence and consequences of hypertension, future research should be aimed at elucidating the roles of biological, environmental, behavioral, and sociocultural variables in the etiology of childhood hypertension.

REFERENCES

(1) Althoff SA, Svoboda M, Girdano DA: *Choices in Health and Fitness for Life.* Scottsdale, AZ: Gorsuch Scarisbrick, 1988.

(2) Strong WB, Deckelbaum RJ, Gidding SS, et al: Integrated cardiovascular health promotion in childhood. *Circulation.* 1992, 85:1638— 1650.

(3) Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure: The fifth report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. *Archives of Internal Medicine.* 1993, 153.154-183,

(4) Mahoney LT, Lauer RM: Consistency of blood pressure levels in children. *Seminars in Nephrology.* 1989, 9:232-235.

(5) Light KC: Psychosocial precursors of hypertension: Experimental evidence. *Circulation.* 1987, 76(Suppl. 1):I-67—I-75.

(6) Herd JA: Cardiovascular response to stress. *Psychological Review.* 1991, 7/:305-329.

(7) Jemerin JM, Boyce WT: Psychobiological differences in childhood stress response U. Cardiovascular markers of vulnerability. *Developmental and Behavioral Pediatrics.* 1990, *11:140-150.*

(8) Krantz DS, Manuck SB: Acute psychophysiologic reactivity and risk of cardiovascular disease: A review and methodologic critique. *Psychological Bulletin.* 1984, 96:435-4-64.

(9) Henry JP, Stephens PM, Santisteban GA: A model of psychosocial hypertension showing reversibility and progression of cardiovascular complications. *Circulation Research.* 1975, *36:156-164.*

(10) Henry JP, Grim CE: Psychosocial mechanisms of primary hypertension. *Journal of Hypertension.* 1990, 8:783-793.

(11) Cobb S, Rose RM: Hypertension, peptic ulcer, and diabetes in air traffic controllers. *Journal of the American Medical Association.* 1973, 224:489-492.

(12) Winkleby MA, Ragland DR, Syme SL: Self-reported stressors and hypertension: Evidence of an inverse association. *American Journal of Epidemiology.* 1988, *127:124-134.*

(13) Ely D, Mastardi RA: The effect of recent life stress, life assets, and temperature pattern on cardiovascular risk factors for Akron City police officers. *Journal of Human Stress.* 1986, *12:77-91.*

(14) Byrne DG: Personality, life events, and cardiovascular disease. *Journal of Psychosomatic Research.* 1978, 31:661-671.

(15) Williams CL, Uchiyama C: Assessment of life events during adolescence: The use of self-report inventories. *Adolescence.* 1989, 24:95-118.

(16) Kearney CA, Drabman RS, Beasley JF: The trials of childhood: The development, reliability, and validity of the Daily Stressor Scale. *Journal of Clinical and Family Studies.* 1993, 2:371-388.

(17) Lazarus RS: *Psychological Stress and the Coping Process.* New York: McGraw-Hill, 1966.

(18) Wagner BM, Compas BE, Howell DC: Daily and major life events: A test of an integrative model of psychosocial stress. *American Journal of Community Psychology.* 1988, *16:189-205.*

(19) DeLongis A, Coyne JC, Dakof G, Folkman F, Lazarus RS: Relationship of daily hassles, uplifts, and major life events to health status. *Health Psychology.* 1982, *1:119-136.*

(20) Croft JB, Keenan NL, Sheridan DP, Wheeler FC, Speers MA: Waist-to-hip ratio in a biracial population: Measurement, implications, and cautions for using guidelines to define high risk for cardiovascular disease. *Journal of the American Dietetic Association.* 1995, 95:60-64.

(21) Harrison GG, Buskirk ER, Carter JEL , et al: Skinfold thicknesses and measurement technique. In Lohman TG, Roche AF, Martorell R (eds), *Anthropometric Standardization Reference Manual.* Champaign, IL: Human Kinetics, 1988, 55-58.

(22) Slaughter MH, Boileau TG, Horswill CA: Skinfold equations for estimation of body fatness in children and youth. *Human Biology.* 1988, 60:709-723.

(23) National High Blood Pressure Education Program Working Group oti Hypertension Control in Children and Adolescents: Update on the 1987 task force on blood pressure control in children: A working group report from the National High Blood Pressure Education Program. *Pediatrics.* 1996, 98:649-658.

(24) Melby CL, Goldflies DG, Hyner GC, Lyle RM: Relation between vegetarian/nonvegetarian diets and blood pressure in Black and White adults, *American Journal of Public Health.* 1989, *79:1283*— 1288.
(25) Sallis JF, Condon SA, Goggin KJ, et al: The development of self-administered physical activity surveys for 4th grade students. *Research Quarterly in Exercise and Sport.* 1993, 64:25-31.
(26) Howard JKH, Bindler RM, Dimico GS, et al: Cardiovascular risk factors in children: A Bloomsday research report. *Journal of Pediatric Nursing.* 1991. 6:222-229.
(27) Compas BE, Davis DE, Forsythe 0, Wagner BM: Assessment of major and daily stressful events during adolescence: The Adolescent Perceived Events Scale. *Journal of Consulting and Clinical Psychology.* 1987, 55:534-541.
(28) Rosner B, Prineas RJ, Loggie JM, Daniels SR: Blood pressure nomograms for children and adolescents, by height, sex, and age, in the United States. *Journal of Pediatrics.* 1993, *123:871-886.*
(29) Lohman TG: *Advances in Body Composition Assessment.* Champaign, IL: Human Kinetics, 1992.
(30) Johnston FE, Hamill PVV, Lemeshow J: *Skinfold Thickness of Children 6-11 Years* (National Health Survey, Series 11, No. 120). Washington, DC: U.S. Government Printing Office, 1982.
(31) Johnston FE, Hamill PVV, Lemeshow J: *Skinfold Thickness of Children 6-11 Years* (National Health Survey, Series 11, No. 132). Washington, DC: U.S. Government Printing Office, 1984.
(32) Ross TI), Dorson CO, Gilbert GG, Katz Si: New standards for fitness measurement. *Journal of Physical Education, Recreation, and Dance.* 1985, 56:62-66.
(33) Gutin B, Basch C, Shea S, et al: Blood pressure, fitness, and fatness in 5- and 6-year-old children. *Journal of the American Medical Association.* 1990, *264:1123-1127.*
(34) Gutin B, Islam S, Manes T, et al: Relation of percentage of body fat and maximal aerobic capacity to risk factors for atherosclerosis and diabetes in Black and White 7- to 11-year-old children. *Journal of Pediatrics.* 1994, /25:847-852.
(35) Wagner BM, Compas BE: Gender, instrumentality, and expressivity: Moderators of the relation between stress and psychological symptoms during adolescence. *American Journal of Community Psychology.* 1990, /8:383-406.
(36) Compas BE, Howell DC, Phares V, Williams RA, Guinta CT: Risk factors for emotional/behavioral problems in young adolescents: A prospective analysis of adolescent and parental stress and symptoms. *Journal of Consulting and Clinical Psychology.* 1989, 57:732-740.
(37) Compas BE, Howell DC, Phares V, Williams RA, LeDoux N: Parent and child stress and symptoms: An integrative analysis. *Developmental Psychology.* 1989, 25:550-559.
(38) Brody MJ, Natelson BH, Anderson EA, et al: Task Force 3: Behavioral mechanisms in hypertension. *Circulation.* 1987, 76(Suppl. 1):1-95—I-99.
(39) Krantz SD, DeQuattro V, Blackburn HW, et al: Task Force 1: Psychosocial factors in hypertension. *Circulation.* 1987, 76(Suppl. 1):1-84-1-88.
(40) Wiist WH, Flack JM: A test of the John Henryism hypothesis: Cholesterol and blood pressure. *Journal of Behavioral Medicine.* 1992, *1515-29.*
(41) Winkleby MA, Jambs DE, Frank E, Fortmann SP: Socioeconomic status and health: How education, income, and occupation contribute to risk factors for cardiovascular disease. *American Journal of Public Health.* 1993, 83:289-290.
(42) Wright LB, Treiber FA, Davis H, Strong WB: Relationship of John Henryism to cardiovascular functioning at rest and during stress in youth. *Annals of Behavioral Medicine.* 1996. *18:146-150.*
(43) Johnson EH, Spielberger CD, Worden Ti, Jacobs GA: Emotional and familial determinants of elevated blood pressure in Black and White adolescent males. *Journal of Psychosomatic Research.* 1987, *31.287*300.