Aggression and Cardiovascular Response in Children

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Objective: To examine cardiovascular response as a function of children's aggression after controlling for the effects of known risk factors.

Method: Participants were 140 children in second, fourth, and sixth grades. Teachers completed the Matthews Youth Test for Health, a measure that includes questions pertaining to children's aggression. Measures of blood pressure and heart rate were obtained during baseline, academic quiz, and recovery.

Results: Increasing age and body mass index were associated with increased cardiovascular responses. Aggressive children exhibited higher heart rates at baseline and lower heart rate reactivity. Aggressive children with a positive parent history of hypertension exhibited the greatest cardiovascular response.

Conclusions: These results provide further support for the identification of behavioral factors that increase cardiovascular risk in children.

Key words: children; cardiovascular response; aggression.

Coronary heart disease (CHD) remains the major cause of mortality of adults in the United States (Centers for Disease Control and Prevention, 1999). Investigation of modifiable risk factors contributing to the development of this disease remains a high priority for behavioral medicine research. Childhood risk factors, including elevated blood pressure levels, parental history of hypertension, obesity, and the Type A behavior pattern, have been identified that predict cardiovascular disease in adulthood (Berenson et al., 1989; Keltikangas-Jarvinen & Raikkonen, 1989). Studies in adults have determined that hostility is a significant independent predictor of coronary heart disease, but few studies have examined this issue in children. Since behavioral risk factors such as hostility are amenable to intervention, early identification of such characteristics is imperative.

Research findings indicate that elevated blood pressure in childhood is predictive of essential hypertension in adulthood (Becket, Rosner, Roche, & Guo, 1992; Webber, Cresanta, Voors, & Berenson, 1983). Cross-sectional pediatric studies have demonstrated that elevated blood pressure is associated with greater left ventricular mass (LVM) in childhood (Janz, Burns, & Mahoney, 1995; Trierbe et al., 1993), which is also a significant predictor of cardiovascular complications in adulthood (Casale et al., 1986). Prospective studies with children have shown that baseline levels of cardiovascular functioning, such as resting blood pressure levels (Urban et al., 1995) and cardiovascular reactivity to acute laboratory stressors (Murdison et al., 1998; Papavasiliou, Trierbe, Strong, Malpass, & Davis, 1996), are independent predictors of future left ventricular mass. The importance of identifying these potential risk factors in childhood is highlighted by longitudinal studies that have demonstrated the stability of blood pressure levels up to a 40-year period.
Various measures have attempted to capture the cognitive, behavioral, and affective aspects of hostility. An extensive review of measures of anger, hostility, and aggression for use with children is available in the literature (Furlong & Smith, 1994). However, reliable and valid measures of hostility for children are limited (Treiber et al., 1989). A behavioral measure of the Type A construct, designed specifically for children, is the Matthews Youth Test for Health (MYTH; Matthews & Angulo, 1980), which includes characteristics related to hostility. The MYTH is composed of two subscales: Competitiveness and Impatience/Aggression. By definition, the aggression items of the Impatience/Aggression subscale of the MYTH appear to be most related to the construct of hostility.

This study investigated children’s cardiovascular (CV) responses to an acute laboratory stressor. The effects of known correlates of CV responses, such as age, gender, body mass index (BMI), and parent history of hypertension, were examined. The primary objective of this study was to examine cardiovascular responses in children as a function of their aggression after controlling for these known correlates of CV response. The relationships between known correlates of CV response and aggression were also investigated to determine if these variables interacted to produce greater levels of CV response. We expected that the presence of known risk factors would be related to increased CV response, as measured by systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR). In addition, we expected that higher aggression scores would be related to increased CV response, especially among those with parental history of hypertension.

**Method**

**Participants**

One hundred fifty-nine children participated in the study. Analyses could not be conducted on 19 of these participants due to missing items on the teacher-completed measure of children’s aggression. Therefore, most analyses were conducted on the 140 children with complete data regarding the aggression measure and CV responses. Analyses involving BMI utilized a slightly smaller sample since this information was missing for an additional 14 subjects. The participants were Caucasian children (61 boys, 79 girls), ages 7 to 13 years old ($M = 9.48, SD = 1.66$). Children were in second ($n = 45$), fourth ($n = 53$), and sixth ($n = 42$) grades. Based on the Four Factor Index of Social Status (Hollingshead, 1975), the socioeco-
omic status (SES) of participants ranged from lower to upper class, with the majority of participants falling within the middle-class range. The distribution of SES was as follows: upper class (3%), middle to upper class (25%), middle class (35%), middle to lower class (28%), and lower class (9%).

**Measures**

**Cardiovascular Response.** Blood pressure and heart rate were measured with a Vita-Stat 900-D automated monitor. Children’s SBP, DBP, and HR were evaluated during an adaptation phase (5 minutes), a first baseline (5 minutes), a math and information quiz (7 minutes), and a second baseline (5 minutes). Three measurements of these CV responses were obtained during each phase. Mean values of these responses were calculated for each phase of measurement. CV reactivity scores were calculated by subtracting the mean values during the baseline from the mean values during the quiz.

**Aggression.** The MYTH (Matthews & Angulo, 1980) is a teacher-rated measure of the behavioral components of the Type A construct and is composed of two factor analytically derived scales: Competitiveness and Impatience/Aggression. Previous research has indicated that reliability for the MYTH is acceptable, with test-retest reliability correlations equal to .82 for the competitiveness factor and .79 for the impatience/aggression factor (Matthews & Angulo, 1980). In addition, internal consistency for the competitiveness factor (α = .89) and the impatience/aggression factor (α = .88) are both adequate (Matthews & Angulo, 1980). Validity of the MYTH was documented in a study in which children classified as Type A were more competitive, aggressive, and impatient in a test setting compared with children classified as Type B (Matthews & Angulo, 1980). Although the MYTH does not measure hostility specifically, four aggression items on the Impatience/Aggression subscale are related to the construct of hostility: (1) it takes a lot to get this child angry at his or her peers; (2) this child gets irritated easily; (3) this child likes to argue or debate; (4) this child tends to get into fights. As more recent research has identified hostility as the cardio-toxic component of Type A behavior (Matthews & Haynes, 1986), hypotheses for this study utilized the sum of the four aggression items on the impatience/aggression factor of the MYTH (i.e., rather than the factor scores or the total MYTH score). A test of internal consistency was performed on these four items for the purposes of this study, indicating adequate internal consistency (α = .75).

**Procedure**

The following procedures were approved by the institutional review board for human subjects. A letter describing the study, a parental consent form, and a child assent form were sent home to parents of all children in the second, fourth, and sixth grades of four urban schools. After consent forms were received by the teachers, a senior undergraduate research assistant conducted telephone interviews with parents of these children regarding parents’ hypertension status (medication usage). Children were rated by their teachers on the MYTH, which provided a measure of children’s tendencies toward aggression. During school hours, children were brought to a private room within the school nurse’s suite to complete study procedures. Each child’s height and weight were measured using a Detecto Medical Scale (Webb City, MO). The quiz contained 20 questions, administered via audiotape, and consisted of items culled from the Arithmetic and Information subtests of the Weschler Intelligence Scale for Children-Revised (WISC-R; Weschler, 1974) and the Mathematics and General Information subtests of the Peabody Individual Achievement Test (PIAT; Dunn & Markwardt, 1970). Items were selected for each grade in order to approximate the 50% difficulty level. The mean number correct of the 20 items administered to all of the children in the study indicated that the items were of moderate difficulty. The mean number correct for grades 2, 4, and 6 were 8.25, 11.85, and 9.83, respectively. Measures of SBP, DBP, and HR were obtained at 1-minute intervals during adaptation (5 minutes), baseline (5 minutes), mild stress (7-minute math and information quiz), and recovery (5 minutes) conditions.

**Results**

**Descriptive Analyses**

Means and standard deviations by gender and grade are listed for CV responses across all phases of the study (see Table I). In this sample, 14% of the children exhibited SBPs (mm/Hg, millimeters mercury) at baseline and 25% exhibited DBPs (mm/Hg) at baseline that were greater than the 95th percentile, as identified by the Report of the Second Task Force on
Blood Pressure Control in Children (1987). The mean BMI for this sample was 17.7 (SD = 3.23). Seven percent of this sample exhibited BMIs greater than the 95th percentile, as compared to standardized percentile curves of BMI for children and adolescents (Hammer, Kraemer, Wilson, Ritter, & Dombusch, 1991). Twenty-three percent of the children in the study had parents with a positive history of hypertension (74% no parent history of hypertension; 3% missing data).

Validity Check of Laboratory Stressor

In order to determine if the academic quiz did indeed increase CV arousal, repeated measures ANOVAs were conducted to investigate changes in children’s CV responses over time (i.e., baseline one, quiz, baseline two). Significant within subjects effects were noted for SBP, F(3, 399) = 33.013, p < .001; DBP, F(3, 399) = 33.465, p < .001; and HR, F(3, 399) = 33.080, p < .001. Post-hoc analyses indicated that there were significant differences between phases of measurement for each form of CV response (see Table II for means and standard deviations). Since measurements during the adaptation phase were utilized to facilitate adjustment to the novel experimental situation, findings regarding responses during this phase were not considered.

Overall, increases in CV response were noted from baseline one to the quiz and decreases in cardiovascular responses were noted from the quiz to baseline two. SBP (mm/Hg) increased from baseline one to the quiz (t[139] = –9.197, p < .001) and decreased from the quiz to baseline two (t[139] = –10.465, p < .001). DBP (mm/Hg) increased from baseline one to the quiz (t[139] = –11.414, p < .001) and decreased from the quiz to baseline two (t[139] = –8.549, p < .001). In addition, HR, as indicated in beats per minute (bpm), increased from baseline one to the quiz (t[139] = –6.693, p < .001) and decreased from the quiz to baseline two (t[139] = –4.415, p < .001). There was no difference between baseline one and baseline two for SBP (t[139] = .109, p = ns); however, for both DBP (t[139] = –3.293, p < .001) and HR (t[139] = –2.131, p < .05), baseline two was significantly greater than baseline one. Mean increases from baseline one to the quiz were 6.06 mm/Hg, 6.85 mm/Hg, and 3.82 bpm for SBP, DBP, and HR, respectively.

Table I. Means and Standard Deviations for CV Response by Grade and Gender

<table>
<thead>
<tr>
<th>CV response</th>
<th>2nd grade</th>
<th>4th grade</th>
<th>6th grade</th>
<th>2nd grade</th>
<th>4th grade</th>
<th>6th grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP (mm/Hg)</td>
<td>Reactivity</td>
<td>4.41 (8.00)</td>
<td>5.74 (9.00)</td>
<td>7.06 (7.22)</td>
<td>5.70 (6.96)</td>
<td>4.78 (6.91)</td>
</tr>
<tr>
<td></td>
<td>Baseline 1</td>
<td>106.90 (8.69)</td>
<td>115.86 (12.71)</td>
<td>118.78 (5.30)</td>
<td>109.35 (8.29)</td>
<td>116.58 (11.71)</td>
</tr>
<tr>
<td></td>
<td>Quiz</td>
<td>111.31 (8.04)</td>
<td>121.60 (14.41)</td>
<td>125.83 (6.73)</td>
<td>115.05 (9.23)</td>
<td>121.36 (11.34)</td>
</tr>
<tr>
<td></td>
<td>Baseline 2</td>
<td>108.10 (10.56)</td>
<td>115.85 (14.59)</td>
<td>118.39 (7.01)</td>
<td>107.32 (6.90)</td>
<td>115.25 (10.36)</td>
</tr>
<tr>
<td>DBP (mm/Hg)</td>
<td>Reactivity</td>
<td>7.68 (6.49)</td>
<td>4.31 (8.93)</td>
<td>8.42 (5.66)</td>
<td>6.93 (8.09)</td>
<td>7.04 (6.53)</td>
</tr>
<tr>
<td></td>
<td>Baseline 1</td>
<td>66.96 (9.07)</td>
<td>74.63 (9.86)</td>
<td>75.53 (7.78)</td>
<td>69.71 (8.71)</td>
<td>76.09 (7.60)</td>
</tr>
<tr>
<td></td>
<td>Quiz</td>
<td>74.64 (11.45)</td>
<td>78.94 (10.83)</td>
<td>83.94 (7.80)</td>
<td>76.64 (10.05)</td>
<td>83.12 (6.61)</td>
</tr>
<tr>
<td></td>
<td>Baseline 2</td>
<td>72.02 (9.22)</td>
<td>75.07 (10.28)</td>
<td>76.33 (6.87)</td>
<td>71.35 (9.18)</td>
<td>78.06 (7.72)</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>Reactivity</td>
<td>3.81 (7.21)</td>
<td>3.18 (8.41)</td>
<td>3.81 (3.88)</td>
<td>3.29 (8.02)</td>
<td>3.28 (5.32)</td>
</tr>
<tr>
<td></td>
<td>Baseline 1</td>
<td>86.57 (13.70)</td>
<td>86.19 (11.01)</td>
<td>80.47 (14.87)</td>
<td>89.48 (5.95)</td>
<td>90.14 (15.62)</td>
</tr>
<tr>
<td></td>
<td>Quiz</td>
<td>90.38 (12.90)</td>
<td>89.37 (10.94)</td>
<td>84.28 (14.77)</td>
<td>92.77 (9.62)</td>
<td>93.42 (14.96)</td>
</tr>
<tr>
<td></td>
<td>Baseline 2</td>
<td>88.77 (15.98)</td>
<td>85.97 (10.91)</td>
<td>81.67 (13.03)</td>
<td>90.73 (7.57)</td>
<td>90.69 (15.67)</td>
</tr>
</tbody>
</table>

Table II. Means and Standard Deviations for CV Responses at Each Measurement Phase

<table>
<thead>
<tr>
<th>CV response</th>
<th>Adaptation</th>
<th>Baseline 1</th>
<th>Quiz</th>
<th>Baseline 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP (mm/Hg)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td></td>
<td>116.82 (11.44)</td>
<td>113.86 (10.70)</td>
<td>119.92 (11.42)</td>
<td>113.80 (11.03)</td>
</tr>
<tr>
<td>DBP (mm/Hg)</td>
<td>76.57 (9.64)</td>
<td>73.57 (9.05)</td>
<td>80.42 (9.73)</td>
<td>75.58 (9.06)</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>82.33 (13.80)</td>
<td>85.54 (12.84)</td>
<td>89.36 (12.48)</td>
<td>86.63 (13.37)</td>
</tr>
</tbody>
</table>
Hierarchical multiple regression analyses were performed in which CV responses were first analyzed as a function of age, gender, BMI, parental history of hypertension in the first step, and aggression in the second step. Examination of individual beta weights in the first step of the regressions performed (see Table III) indicated that parental hypertension did not offer any unique contribution to the variance explained. Girls exhibited greater DBP during the quiz than boys. Children with greater BMI exhibited increased SBP at baseline, SBP during the quiz, DBP at baseline, DBP during the quiz, and HR at baseline. Children with greater BMI exhibited decreased HR reactivity. As children's ages increased, they demonstrated increased SBP and DBP at both baseline and during the quiz. Older children also exhibited lower HR during baseline and quiz relative to younger children.

### Effects of Known Correlates of CV Response

Hierarchical multiple regression analyses were performed in which CV responses were first analyzed as a function of age, gender, BMI, parental history of hypertension in the first step, and aggression in the second step. Examination of individual beta weights in the first step of the regressions performed (see Table III) indicated that parental hypertension did not offer any unique contribution to the variance explained. Girls exhibited greater DBP during the quiz than boys. Children with greater BMI exhibited increased SBP at baseline, SBP during the quiz, DBP at baseline, DBP during the quiz, and HR at baseline. Children with greater BMI exhibited decreased HR reactivity. As children's ages increased, they demonstrated increased SBP and DBP at both baseline and during the quiz. Older children also exhibited lower HR during baseline and quiz relative to younger children.

### Unique Effects of Aggression on CV Response

Children's scores on aggression items explained an additional 3.9% of the variance in children's heart rate at baseline ($t = 2.33, p < .05$) and an additional 3.9% of the variance in children's heart rate reactivity ($t = -2.29, p < .05$), indicating higher heart rates at baseline and lower heart rate reactivity. These items did not account for unique variance in any of the other CV measures. Table IV lists the beta weights for aggression items across CV responses.

### Interactions with Aggression

A series of ANOVAs were conducted to investigate potential interactions between children's aggressive-
indicated that children in second grade demonstrated significantly lower SBP and DBP than children in fourth and sixth grades. Children in sixth grade had significantly lower HR than children in second and fourth grades. A 3 × 2 ANCOVA, controlling for baseline SBP, indicated that children in higher grades also exhibited increased SBP during the quiz, \( F(2, 139) = 4.55, p < .01 \). Fisher’s LSD indicated that children in sixth grade exhibited higher SBP during the quiz than children in second and fourth grades. No interaction effects were noted between grade and aggression.

Aggression and Gender Interactions. In 2 × 2 ANOVAs investigating the effects of gender and aggression, girls exhibited higher DBP at baseline, \( F(1, 139) = 4.014, p < .05 \), than boys. A significant interaction between gender and aggression was noted, \( F(1, 139) = 4.42, p < .05 \), with heart rate reactivity being greater for nonaggressive males than aggressive males (\( t[59] = 2.72, p < .01 \)), whereas no differences in heart rate reactivity were noted between nonaggressive and aggressive females (\( t[77] = .00, p = ns \)). ANCOVAs did not reveal any significant differences between genders during the quiz, after controlling for baseline cardiovascular responses. Analyses of SBP and DBP reactivity did not reveal significant interactions.

Aggression and Parent History Interactions. In 2 × 2 ANOVAs analyzing the effects of aggression and parent history of hypertension, significant interactions were obtained between aggression and parent history of hypertension on SBP at baseline, \( F(1, 134) = 3.65, p < .05 \), and DBP at baseline, \( F(1, 134) = 5.59, p < .05 \), indicating that aggressive children who had a positive parent history of hypertension had higher SBP and DBP at baseline, whereas nonaggressive children with a positive parent history of hypertension exhibited the lowest cardiovascular responses. As shown in Figure 1 aggressive children with a positive parent history of hypertension exhibit significantly higher DBP at baseline than nonaggressive children with a positive parent history of hypertension (\( t[30] = -7.74, p < .05 \)); however, no other significant simple effects were noted. ANCOVAs did not reveal any significant differences between these groups during the quiz, after controlling for baseline cardiovascular responses.

Discussion

This study investigated children’s CV responses to an acute laboratory stressor, an academic quiz of moderate difficulty. CV responses at the various stages of the study indicated that the quiz was affective at increasing children’s CV arousal. One goal of this study was to replicate previous studies that have identified correlates of CV response in children. Consistent with previous findings (Lauer, Connor, Leaverton, Reiter, & Clarke, 1975; Matthews & Stoney, 1988; Voors, Webber, & Berenson, 1978), age and BMI were associated with higher cardiovascular responses. These findings indicated that at baseline and quiz, increases in age were associated with greater SBP and DBP and lower HR. Also congruent with previous findings, increases in BMI were associated with higher SBP and DBP at both baseline and quiz. This is consistent with previous research indicating that obesity in childhood is related to elevations in blood pressure (e.g., Ferrannini, Haffner, Mitchell, & Stern, 1991).

The primary goal of this study was to determine if children’s aggression explained additional variance in children’s CV responses after controlling for the effects of known correlates of CV response. The results indicated that aggressive children did in fact exhibit increased heart rate at baseline as compared to their nonaggressive counterparts. Although aggression/anger is only one component of Type A behavior, these results are consistent with past research suggesting that Type A behavior in male children is associated with a higher mean heart rate (Lawler et al., 1981). Similarly, Dembroski and his colleagues have demonstrated that Type A college students show greater heart rate variability at rest (Dembroski, MacDougall, & Shields, 1977; Dembroski, MacDougall, Shields, Petitto, & Lushene, 1978).

Aggressive children also displayed lower heart rate reactivity. These results may be due to a ceiling effect from higher heart rate levels at baseline. However, these results might also be interpreted in light of research that has demonstrated that chronic aggression or conduct problems in children and adolescents are associated with lower autonomic activity
were not verified by physician records, some parents' ing medication for hypertension. Since these reports reported whether either of the child's parents was tak-

on a telephone conversation in which the parent re-

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gested that the relationship between family history

sponses than nonaggressive children with a negative

positive parent history would exhibit lower CV re-

It was unexpected that nonaggressive children with a

more pronounced in children who exhibit Type A

behavior, of which anger/aggression is a component.

Once again, this finding is consistent with the find-

ings relating autonomic underarousal to conduct

problems in children; however, the reason why this

relationship was found to be more salient in boys

than girls is unclear.

Consistent with hypotheses, a significant inter-

action between parent history of hypertension and

aggressiveness was obtained, whereby aggressive

children with a positive parent history of hyperten-
sion exhibited elevated SBP and DBP. These results are consistent with past research studies that have found clear associations between parental hypertension and CV responses (Lawler et al., 1998; Musante, Treiber, Strong, & Levy, 1990). McCann and Mathews (1988) also demonstrated that the relationship between parental hypertension and CV response is more pronounced in children who exhibit Type A behavior, of which anger/aggression is a component. It was unexpected that nonaggressive children with a positive parent history would exhibit lower CV responses than nonaggressive children with a negative parent history. However, some studies have sug-

gested that the relationship between family history and CV reactivity may be affected by gender and personality characteristics, such as defensiveness (Shapiro, Goldstein, & Jamner, 1995).

These findings should be interpreted in light of the fact that parental hypertension status was based on a telephone conversation in which the parent reported whether either of the child's parents was tak-

ing medication for hypertension. Since these reports were not verified by physician records, some parents' self-report of negative histories may reflect the fact that they have not seen a physician in several years and are unaware of their hypertension status. Therefore, false negatives may be inaccurately driving the DBP of the negative parent history group upward, contributing to the unexpected findings.

Although this study provided an indicator of the unique effects of anger/aggression on children's CV response, other important components of hostility, such as suspiciousness, cynicism, and a disregard for societal rules and norms, were not assessed. Future researchers examining the effects of hostility on CV response in children should attempt to assess all aspects of hostility, including its cognitive, affective, and behavioral components, using various measure-

ment approaches (e.g., behavioral observation, self-

report rating scales) and multiple informants (e.g., child, parent, teacher).

Another potential limitation of this study concerns the type of stressor utilized. Suls and Wan (1993) found that when research studies used inter-

personal stressors that evoked feelings of mistrust, hostile interpersonal style was predictive of cardio-

vascular responses. This study utilized a traditional laboratory stressor, an academic quiz of moderate dif-


culty. Cardiovascular reactivity data indicated that the quiz was effective at increasing cardiovascular arousal. Also, a differential response in heart rate re-

activity was obtained based on children's aggressiveness; however, it is conceivable that more substantial findings would have been achieved if an interper-

sonal stressor had been used.

A growing body of literature suggests that the relationship between CV response and hostility varies across ethnic groups. This study was limited by the fact that the sample consisted of only Caucasian chil-

dren. Recent research has demonstrated that children's hostility may be predictive of cardiovascular reactivity in African American children, but not in Caucasian children (Gump, Matthews, & Raikkonen, 1999). Differences in cardiovascular responses across ethnic groups were also demonstrated in a study that found that African American males under high levels of stress and who experienced suppressed hostility had the highest blood pressure levels compared to all other groups (Harburg et al., 1995). These findings suggest that future research regarding the relationship between cardiovascular response and hostility utilize ethnically diverse samples.

Overall, this study provides further support for the identification of behavioral factors that increase cardiovascular risk in children. The current results
suggest that aggressive children exhibit increased HR at baseline and decreased HR reactivity. Aggressive children with a hypertensive parent exhibit higher SBP and DBP at baseline. In addition, greater BMI in children was associated with increased CV response throughout all phases of the study. These results provide further support for the role of obesity and aggression as modifiable risk factors for coronary heart disease. Interventions to address both obesity and aggression in children may be helpful in reducing risk for the development of coronary heart disease.

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References


