Cardiovascular Reactivity and Adolescent Boys’ Physical Health

Patricia L. Dobkin, PhD*; Richard E. Tremblay, PhD‡; and Frank A. Treiber, PhD§

ABSTRACT. Objective. Minor illnesses and major diseases are affected by individual, environmental, and social factors. The purpose of the study was to determine if cardiovascular reactivity, an individual characteristic, was related to adolescent boys’ health status and behaviors.

Methods. A total of 89 low socioeconomic status 16-year-old boys who had been classified using teacher ratings during childhood as anxious, disruptive, anxious—disruptive, or normal participated in a laboratory stress experiment. Systolic blood pressure (SBP) and diastolic blood pressure were measured during the Social Competence Interview. Using the upper and lower quartiles of SBP change scores, 21 boys were classified as reactors and 20 boys were classified as nonreactors. Subjects were interviewed to assess health behaviors and outcomes, as well as stressful life events.

Results. No significant group differences were found for minor or major physical health problems. A logistic regression analysis indicated that risky health behaviors were associated with SBP reactivity, personality characteristics, and negative life events. Specifically, nonreactors, who were disruptive, had more negative life events and engaged in more health-compromising behaviors (eg, smoking cigarettes, unprotected sex), which may contribute to future health problems (eg, cancer, AIDS). Anxious individuals may be more vulnerable to cardiovascular diseases in part because of exaggerated cardiovascular reactivity to stress.

Conclusion. Low socioeconomic status boys may be at risk for different health problems caused by differing personality characteristics associated with divergent health-related behaviors. Pediatrics 1998;101(3). URL: http://www.pediatrics.org/cgi/content/full/101/3/e11; adolescents, cardiovascular reactivity, physical health.

ABBREVIATIONS. CVR, cardiovascular reactivity; SES, socioeconomic status; SBP, systolic blood pressure; SCI, Social Competence Interview; APES, Adolescent Perceived Life Events Survey; DBP, diastolic blood pressure.

Cardiovascular reactivity (CVR) has been considered a role in the etiology and/or exacerbation of numerous stress-related health problems ranging from minor illnesses (eg, colds) to major diseases (eg, essential hypertension, coronary artery disease). Pediatric studies have demonstrated that reactors can be identified very early in life and that reactivity is a stable phenomenon. Initially, pediatric CVR research focused on relationships with physical cardiovascular disease risk factors, such as family history of essential hypertension, gender, adiposity, sexual maturation, and race, but more recently, a variety of psychosocial factors have been studied. In particular, individual characteristics such as temperament, psychological factors such as negative affect, and social influences such as family life have called attention to the multidetermined nature of CVR.

Personality characteristics have long been considered important determinants of physical health in adults, and more recently in children and adolescents. Matthews et al and others have observed that type A children frequently exhibited exaggerated cardiovascular responses to laboratory and real life stressors. Kagan et al and Beidel have studied young inhibited/anxious children and found that anxious individuals are more reactive to psychosocial stressors. Another personality characteristic that has received increasing attention is anger/hostility. In fact, it is generally believed that this is the cardinal component of the type A pattern that puts individuals at risk. Although not entirely consistent, self-reported manifestations of anger expression and hostility have been associated with increased blood pressure at rest and in response to behavioral stressors. Interestingly, antisocial youth (eg, disruptive, delinquent, impulsive) also have been studied. These youth are at risk for a number of poor physical health outcomes, but possibly via mechanisms other than CVR to stress (eg, smoking, excessive alcohol intake, and accidents leading to injury). Environmental factors also have been evaluated as determinants of health outcomes. Research has shown a consistent relationship between life events and negative mental and physical health outcomes. When considering children and adolescents, family factors are viewed as crucial to health, especially when family life is burdened by poverty, marital conflict, parental psychopathology, and other disadvantages.

Friedman et al highlight the fact that certain people are vulnerable or resilient to health problems as a function of temperament and early socialization, bringing together both personality characteristics and environmental factors. For example, vulnerable individuals from poor socioeconomic status (SES) environments frequently experience chronic negative affect and engage in unhealthy lifestyle behav-
iors, which in turn increase their relative risk. Empirical work reported by Boyce and colleagues support the notion that personal and environmental factors interact. They found that children who were physiologically reactive to behavioral stressors were more likely to experience respiratory illness when they lived in high-stress environments, but not when they lived in low-stress environments. The purpose of the present study was to examine further the relationship between exaggerated CVR to stress and health behaviors and related health outcomes in a community sample of adolescent boys. Importantly, all subjects originated from low SES backgrounds, which places them at increased risk for numerous health problems.

**METHOD**

**Participants**

A cohort of boys from 53 low SES area schools in Montreal, Canada, was followed yearly from kindergarten through 16 years of age. To obtain a homogeneous sample from a cultural perspective, all eligible participants were originally retained only if their parents did not have more than a high school education (mean = 10 years), and if both parents were born in Canada, were Caucasian, and were French-speaking. A subsample of 303 were discussed a recent socially stressful event from a list of problems that places them at increased risk for numerous health problems.

**Procedures**

The study was approved by the Université de Montréal ethics committee. Before study entry, informed consent was obtained from the boy and his mother, father, or legal guardian. After measurement of height and weight, the boy was escorted to a sound-proof, temperature-controlled room with a two-way mirror that allowed for nonintrusive observation. Participants completed a brief questionnaire assessing compliance to avoidance of caffeine, alcohol, nicotine, and nonprescription drugs for 4 hours before experimentation. The cardiovascular monitoring equipment was explained to the boy, and an appropriate blood pressure cuff and electrodes were attached. The experimental design consisted of a 20-minute adaptation period (15 minutes of relaxing music, followed by 5 minutes of silence), presentation of the event through the use of guided imagery and reflective listening. The interviewer attempted to promote accurate reexperiencing of the event through the use of guided imagery and reflective listening. The interviewers were two female university students, trained and supervised by P.L.D.

**Questionnaires**

**Self-report of Recent Substance Intake**

A brief questionnaire assessing use of various substances for 4 hours preceding the study (eg, cigarettes, caffeine, alcohol, nonprescription drugs, and prescriptive medications) that may confound cardiovascular measures was completed before testing.

**Stressor Rating Scale**

Immediately after the SCI, the participant completed five questions that assessed his levels of involvement, anger, discomfort, feeling “nervous,” and realism of the interview, using Likert scale format (1 = none to 5 = very much).

**Adolescent Perceived Life Events Survey (APES)**

The APES is a 100-item self-report inventory designed to measure major and minor life events in children and adolescents. The respondent selects items he has experienced within the past year and indicates on an eight-point scale (4 to 4) his perception (ie, negative or positive) of them. A negative life event score was computed. The APES has been shown to be reliable and valid. The midadolescent form was used with the boys in this study.

**Physical Health**

Items from the 1987 and 1992 Quebec Health Survey were selected; for the purposes of this study, only items related to physical health are reported. Specifically, adolescent responses to questions pertaining to healthy or risky behaviors (eg, physical activity, adequate sleep, breakfast habits, bike helmet use, substance use, condom use, number of sexual partners, same-sex partners), and physical health outcomes (eg, types of illness, use of medical services, medications, accidents, injuries) were retained. The boys’ mothers provided demographic data (eg, age, family structure, income level) and information about family members’ physical health.

**Family Adversity Index**

The Family Adversity Index is derived from demographic and socioeconomic information obtained by the mother during the annual assessments. It comprises seven variables: age of the mother at the child’s birth, age of the father at the child’s birth, educational level of the mother, educational level of the father, mother’s occupational level, father’s occupational level, and family status (intact or not). A score of 1 was assigned to each variable below the 30th percentile in the longitudinal sample, and a score of 0 was assigned to variables above the cutoff. For nonintact family status, a score of 1 was assigned if the child was not living with both biological parents. The Family Adversity Index yielded a theoretic maximum score of 7 and a minimum of 0, which was the case with the current sample. The total score was divided by 7 to yield a factor between 0 and 1. A high score indicates more adversity.

**RESULTS**

**Data Reduction/Statistical Analyses**

Data were reduced for SBP values by averaging readings for each parameter measured during the
resting and stressor periods. Cardiovascular reactivity change scores then were calculated by subtracting the mean resting value from the mean obtained during the SCI.

Individuals whose scores were in the top and bottom quartiles were used in the analyses presented below.

Univariate tests (Student’s t test) were used to analyze the continuous data. χ² tests were used for categorical data. Logistic regression analysis (using Statistical Package for the Social Sciences, SPSS, Chicago, IL) was used to predict the Risky Behavior Index (with a score of 2 to dichotomize the groups; ie, 0 to 1 risky behaviors vs 2 to 5 risky behaviors). The index score was dichotomized because the observed distribution was skewed. A backward procedure was used in which variables were entered and then removed if their contribution was P > .15. The following variables were entered into the equation: Family Adversity Index, SBP reactivity, anxious and disruptive characteristics during childhood, negative life events, as well as two interaction terms (Family Adversity Index × SBPΔ and negative life events × SBPΔ).

**Descriptive Characteristics**

As shown in Table 1, there were no significant differences between the reactors and nonreactors in terms of age, height, weight, body mass index, or self-report of negative or positive life events. Family adversity, which ranged from 0 to .86, (mean = .35; SD = .24, for the two groups combined), tended (P < .09) to be higher in the nonreactors. This indicates that they resided in less advantaged homes. A trend was found indicating that reactors were more likely to have parental history of essential hypertension (P < .07).

**Self-report**

With regard to substances consumed during the 4 hours before the experiment, there was a significant difference for use of cigarettes, χ² (1, n = 43) = 3.99, P < .05, with the nonreactors smoking more (27.3%) than the reactors (4.8%). No significant differences for the use of any other substances with the potential to confound cardiovascular measures were found. There were no significant group differences in levels of involvement or affective responsivity to the SCI or negative or positive stress as assessed by the APES.

As a manipulation check to verify whether the SCI was a stressful experience, Pearson correlation coefficients were computed for heart rate change scores and feeling uncomfortable during the interview. There was a significant correlation (r = .45, P < .007) indicating that boys who were more uncomfortable reacted more. Similarly, the mean heart rate during the interview was significantly correlated with being “nervous” (r = .30, P < .05).

**Physical Health**

Reactors had significantly higher diastolic blood pressure (DBP) mean change scores during the interview (t1,41 = -5.57, P < .001; reactors’ mean = 15.02, SD = 6.02; nonreactors’ mean = 2.98, SD = 7.97). No significant differences were found for major (eg, arthritis, diabetes, cancer) or minor (eg, skin disorders, headaches, allergies, digestive problems) health problems experienced during the past year. Table 2 shows the types of illnesses reported by group.

**Personality Characteristics**

The Social Behavioral Questionnaire data completed previously by teachers were used to examine the distribution of reactors and nonreactors in terms of their personality characteristics. χ² analysis showed that reactors were more likely to be anxious or anxious–disruptive (55.6% and 88.9%, respectively), whereas nonreactors were normal (ie, controls) or disruptive (63.6% and 71.4%, respectively) χ² (3, n = 43) = 8.92; P < .03.

**Health Behaviors**

As detailed in Dobkin et al, a Risky Behavior Index was created by combining the following variables: smokes cigarettes, above average use of alcohol, use of other drugs, failure to use bike helmet, at least one risky sexual behavior. The nonreactors were twice as likely to score high on this index compared with the reactors (57.1% vs 25%, respectively), χ² (1, n = 42) = 4.36; P < .04.

Results from the logistic regression analysis indicated that SBP reactivity (P < .05), anxiety (P < .01), disruptiveness (P < .03), and negative life events

<table>
<thead>
<tr>
<th>TABLE 1. Descriptive Characteristics by Reactivity Classification</th>
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<tbody>
<tr>
<td>Reactors (n = 21)</td>
</tr>
<tr>
<td>Age (y)</td>
</tr>
<tr>
<td>Height (cm)</td>
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<tr>
<td>Weight (kg)</td>
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<tr>
<td>Body mass index (kg/cm²)</td>
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<tr>
<td>Boys’ negative life events</td>
</tr>
<tr>
<td>Positive life events</td>
</tr>
<tr>
<td>Family Adversity Index</td>
</tr>
<tr>
<td>Family history of hypertension (%)</td>
</tr>
<tr>
<td>Personality characteristics (%)</td>
</tr>
<tr>
<td>Anxious</td>
</tr>
<tr>
<td>Disruptive</td>
</tr>
<tr>
<td>Anxious–disruptive</td>
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</tbody>
</table>

* P < .03.

<table>
<thead>
<tr>
<th>TABLE 2. Health Outcomes by Group</th>
</tr>
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<tbody>
<tr>
<td>Reactors (n = 21)</td>
</tr>
<tr>
<td>Minor illness (combined)</td>
</tr>
<tr>
<td>Allergies</td>
</tr>
<tr>
<td>Major illnesses (combined)</td>
</tr>
<tr>
<td>Migraine</td>
</tr>
<tr>
<td>Back pain</td>
</tr>
<tr>
<td>Respiratory</td>
</tr>
<tr>
<td>Thyroid</td>
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<tr>
<td>Bone disease</td>
</tr>
</tbody>
</table>

* All data are reported in percents.

* Illnesses (eg, cancer) that were not present in either group are not reported.
(P < .04) predicted overall risk behavior in 71.8% of the adolescents (76.7% low-risk and 65.7% high-risk subjects were classified correctly). Family adversity was not found to be a significant predictor nor were the interactions between family adversity and SBP reactivity or negative life events and SBP reactivity. Thus, increased risky behaviors were related to being less reactive (SBP), being more disruptive, and having more negative life events. These findings are shown in Table 3.

**DISCUSSION**

Several interesting differences in current health-related behaviors and stable behavioral characteristics were observed between a group of adolescent boys classified as reactors versus nonreactors to a social stressor. The reactive group was less likely to engage in high-risk health behaviors including smoking cigarettes, use of alcohol and other drugs, and engaging in unprotected sexual intercourse, compared with their nonreactive peers. There were no significant differences between groups in history of minor illnesses or major diseases.

To our knowledge, this is the second study to link CVR to risk behaviors in boys. Liang et al.\(^3\) tested 24 boys 14 to 16 years old. They used similar measures including the SCI as one of three laboratory stressors. A hierarchical multivariate regression analysis indicated that 40% of risk behavior was accounted for by an interaction between recent positive life events and mean arterial blood pressure reactivity. This finding was interpreted to mean that the presence of positive life experiences was related to an exceptionally low rate of risk behavior among individuals with high blood pressure reactivity. In our study, engagement in risky behaviors was predicted by low SBP reactivity, disruptive behaviors, and negative life events. However, an interaction between SBP reactivity and stressful environmental conditions (ie, negative life events or family adversity) was not observed.

The failure to find an interaction effect for family adversity and SBP reactivity may have resulted from the nature of the family adversity measure, that is, it captures mostly SES-related data (eg, parents’ occupation and education). Relationships between family environment and children’s physiologic reactivity to stress have been found when family characteristics are assessed more directly. For example, Wright et al.\(^9\) found that maternal reports of greater cohesion and expressiveness were related to less increases in SBP and systemic vascular resistance in response to a laboratory stressor (forehead cold) in 6- to 8-year-old children. In the same study, fathers’ reports of greater control (often present in families with disruptive children) were associated with greater DBP and vascular resistance increases to laboratory stressors (forehead cold and exercise).

It is interesting to note that reactors were likely to have been classified as anxious or anxious-disruptive during childhood based on kindergarten and primary school teacher ratings. This finding corroborates Boyce and coworkers.\(^15\) view that temperament-related behaviors such as inhibition and aggression are correlates of autonomic reactivity to stress in children. Why then were those youth classified as being disruptive the least reactive? If the theory concerning disruptive children being autonomically underaroused is correct,\(^34\) then it follows that they may seek out stimulation (ie, take risks) that may eventually lead to health problems (eg, accidents). A more complete answer to the apparent inconsistency in findings regarding under- or overarousal in these boys was provided by Raine and colleagues,\(^35,36\) who conducted a 14-year prospective study beginning with 15-year-old antisocial boys. These authors found two types of antisocial boys, those who “desist” (ie, do not continue to act out into adulthood) and those who go on to become criminals. Desisters had high resting heart rate at age 15, whereas the future criminals had low resting heart rate, compared with controls. Raine and colleagues’ boys were not assessed for internalizing problems; perhaps their desisters resemble our anxious-disruptive group.

Although intriguing, the current findings should be viewed as tentative for several reasons. First, the sample size is small (albeit larger than that studied by Liang et al.\(^33\)) and stems from a low SES, urban all-male cohort, limiting generalizability. Second, classification of anxiety, although based on several years of teacher ratings, may have been less than optimal given its lower reliability (α = .73) compared with disruptiveness (α = .93). It is possible that at age 16 years, the use of self-report is preferable for assessment of internalizing disorders.\(^37\) Third, the family adversity measure was limited and may not have captured family characteristics that contribute to children’s responses to stress. Nevertheless, the findings are provocative and support the need for additional research examining relationships between physiologic reactivity and health.

**ACKNOWLEDGMENTS**

This work was supported by grants from the National Health Research and Development Program, the Social Sciences and Humanities Research Council of Canada, and Quebec’s CQRS and FCAR funding programs.

We thank the following individuals who made this study possible: Dr W. Thomas Boyce, whose programmatic research, in general, and recent keynote address to the Society of Psychosomatic Research in Santa Fe, New Mexico (1997), in particular, have contributed to the conceptualization of this work. We also thank Ms Lyse Desmarais-Gervais, Ms Hélène Boucheune, and Ms Hélène Boileau, who managed the data; Mr Pierre McDuff, who conducted the data analyses, and Ms Diane Telmosse, who prepared the manuscript. Finally, we thank the boys and their families for participating in our ongoing longitudinal study.

**TABLE 3.** Logistic Regression for the Risky Behavior Index

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>χ²(1)</th>
<th>Exp(B)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Adversity Index</td>
<td>-1.40</td>
<td>1.66</td>
<td>0.71</td>
<td>0.25</td>
<td>.39</td>
</tr>
<tr>
<td>SBP reactivity</td>
<td>-0.13</td>
<td>0.06</td>
<td>4.42</td>
<td>0.87</td>
<td>.04</td>
</tr>
<tr>
<td>Anxious</td>
<td>0.73</td>
<td>0.29</td>
<td>6.34</td>
<td>2.08</td>
<td>.01</td>
</tr>
<tr>
<td>Disruptive</td>
<td>-0.71</td>
<td>0.33</td>
<td>4.80</td>
<td>0.49</td>
<td>.03</td>
</tr>
<tr>
<td>Negative life events</td>
<td>-0.03</td>
<td>0.13</td>
<td>4.20</td>
<td>0.97</td>
<td>.04</td>
</tr>
<tr>
<td>Family adversity × SBP reactivity</td>
<td>0.20</td>
<td>0.16</td>
<td>1.65</td>
<td>1.22</td>
<td>.19</td>
</tr>
</tbody>
</table>

N = 78.
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