

# Self-Reported and Laboratory-Based Responses to Stress in Children with Recurrent Pain and Anxiety

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**Objective** To examine heart rate (HR) responses to and coping with stress in children with recurrent abdominal pain (RAP), anxiety, and healthy controls. **Methods** A clinical sample (children with RAP and children with anxiety) was compared to control children on self-reported and HR responses to stress and a laboratory test of pain tolerance and intensity (cold pressor). **Results** Children in the clinical sample had elevated HRs compared to healthy controls before, during, and after laboratory tasks. Self-reported stress reactivity to social stress was positively correlated with HR at all study time intervals. Secondary control coping with social stress was negatively correlated with HR at most study time intervals. Internalizing symptoms were positively correlated with HR and self-reported stress reactivity. **Conclusions** Stress reactivity, as reflected in both self-reported and HR responses to laboratory stressors, is related to the presence of both RAP and anxiety in children.

**Key words** adolescents; anxiety; children; chronic and recurrent pain; stress, coping.

Recurrent abdominal pain (RAP) is the most common recurrent pain complaint of childhood (McGrath, 1990) affecting 8–25% of children aged 9–12 years (Alfven, 1993; Hyams, Burke, Davis, Rzepski, & Andrulonis, 1996). Fewer than 5% of children evaluated for RAP in primary-care settings show an organic cause for their abdominal pain (Croffi, Fitzgerald, & Chong, 2000; Stickler & Murphy, 1979; Walker, Garber, Van Slyke, & Greene, 1995). One-third to one-half of children with RAP continue to complain of abdominal pain and related symptoms after they reach adulthood (Walker et al., 1995). RAP is associated with significant functional disability in children, including increased restrictions in daily activities due to their pain (Roth-Isigkeit, Raspe, Stoven, Thyen, & Schmucker, 2003) and decreased ability to participate in sports, hobbies, or spend time with friends (Roth-Isigkeit, Thyen, Stoven, Scharzenberger, & Schmucker, 2005).

Research examining the psychological correlates of RAP in children has shown that anxiety symptoms and disorders in particular are common (e.g., Blanchard

& Scharff, 2002; Dorn et al., 2003; Dufton, Dunn & Compas, 2009). When compared to healthy controls, children with RAP are characterized by higher levels of anxiety symptoms with effect sizes ranging from moderate to large (Dufton & Compas, 2010). When compared to children with an organic cause for their stomach pain, children with RAP displayed a moderately higher level of anxiety (Garber, Zeman, & Walker, 1990; Walker, Garber, & Greene, 1993; Walker & Greene, 1989). Studies using structured diagnostic interviews have shown that a high proportion of children with RAP meet criteria for Generalized Anxiety Disorder, Separation Anxiety Disorder, and Social Phobia (Campo et al., 2004; Dorn et al., 2003; Dufton et al., 2009; Garber et al., 1990). Anxiety appears to be a major concern in this population; children with RAP not only have higher than average symptoms of anxiety, but also their levels of anxiety are often severe enough to qualify for a diagnosis.

Somatic symptoms, and stomachaches in particular, are common in childhood anxiety. The *Diagnostic and*

*Statistical Manual, 4th edition* (DSM-IV), which provides descriptions and criteria for mental health diagnoses, includes stomachaches as symptoms in two of its childhood anxiety diagnoses: Separation Anxiety Disorder and Generalized Anxiety Disorder (American Psychiatric Association, 1994). Studies using clinically referred samples have shown that children with anxiety disorders report high rates of stomachaches and other somatic symptoms (e.g., Ginsburg et al., 2006; Last, 1991; Livingston, Taylor, & Crawford, 1988). Ginsburg et al. (2006) evaluated the prevalence of somatic symptoms in children and adolescents with anxiety disorders and found that stomachaches were identified in 70% of their sample. Thus, just as anxiety is common to children with RAP, abdominal pain and stomachaches are similarly common to children with anxiety.

Research establishing a relationship between RAP and symptoms and diagnoses of anxiety raises questions about the processes or mechanisms that may be common to these syndromes. One promising avenue of research that may provide insight into the shared contributions to RAP and anxiety comes from understanding the way children react to and cope with stress. Stress is implicated in RAP in at least two ways (Compas & Boyer, 2001). First, acute and chronic stress can contribute to the onset and course of RAP. Walker, Garber, Smith, Van Slyke, and Claar (2001) found that children with RAP reported more daily stressors than well children, and that daily stressors more strongly predicted somatic symptoms in children with RAP than controls, suggesting that children with RAP are more likely to respond to stress with somatic symptoms than are healthy children. Stress may also be related to decreased pain tolerance in children with RAP. Dufton et al. (2008) found that children with RAP showed decreased pain tolerance after experiencing stress in the lab. These findings suggest that stress reactivity may contribute to increased pain sensitivity in children with RAP that may contribute to the onset of physical symptoms. Second, pain itself may be experienced as a significant stressor (Compas & Boyer, 2001). Pain is a signal of threat to the health and well-being of the child, and it is a noxious internal state that may challenge or exceed the child's adaptive capacities and thus make it difficult for them to cope (e.g., Thomsen et al., 2002).

Responses to stress include both automatic and controlled processes (e.g., Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001; Werner & Gross, 2010). Coping includes responses to stress that are controlled, conscious, and volitional efforts to regulate emotions, behaviors, thoughts, or physiological reactions (Compas et al., 2001). In contrast, automatic processes reflect

physiological, emotional, and behavioral reactivity to stress (Compas et al., 2001). Studies of coping with stress in children with RAP have shown that using primary control (or active) coping strategies focused on changing the source of stress or one's emotions (e.g., problem solving, emotional expression, emotion regulation) and/or adapting to the source of stress through secondary control (or accommodative) coping (e.g., acceptance, distraction, cognitive restructuring) are associated with better adjustment and adaptation in response to pain episodes (e.g., Thomsen et al., 2002; Walker, Smith, & Van Slyke, 1997). In a latent variable analysis of coping with both parent- and child-reports of how children coped with RAP, Compas et al. (2006) found that children who used secondary control coping strategies showed lower levels of anxiety, depression, and somatic complaints. Children who used disengagement coping strategies showed higher levels of psychological and somatic symptoms.

To date, few studies have examined the automatic, physiological responses to stress in children with RAP. Dorn et al. (2003) compared RAP, anxious and well children on a number of physiological and psychological indices before, during, and after a social and cognitive stress task and found that children with RAP and children with anxiety had larger physiological responses to laboratory stressors than controls. Both RAP and anxious children had higher stable heart rates (HRs) than controls, and their systolic blood pressure increased significantly more during the stressor than in the well children. Dufton et al. (2008) also examined physiological responses in a laboratory study in which children with RAP were randomly assigned to experience social and academic stressors either before or after a mild laboratory pain task. Dufton et al. found that some children with RAP showed increases in HR in response to the laboratory stressors, whereas others showed a decrease in HR. Dufton et al. were not able to account for individual differences in HR reactivity to stress in their sample and hypothesized that the high baseline levels of HR in their sample allowed little room for change in response to the stressors. One possible resolution to this problem is to include a comparison sample of healthy children. These initial findings suggest a need for additional research examining responses to stress in children with RAP.

The current study used multiple methods to measure responses to stress in children with RAP, children with anxiety, and healthy control children. HR (as an indicator of autonomic nervous system arousal) in response to a social stressor (the Ewart Social Competency Interview; Ewart & Kolodner, 1991), an academic stressor (serial subtraction), and a pain stressor (the cold pressor task)

was examined. Self- and parent-reports of internalizing and externalizing symptoms were assessed along with self-reported coping with and reactions to social stress.

This study builds upon Dufton et al. (2009), which compared children with RAP and children with anxiety on measures assessing anxiety symptoms and diagnoses. Children with RAP had significantly higher levels of anxiety symptoms and anxiety disorder diagnoses than a healthy comparison group. The anxiety group also endorsed a significant number of somatic symptoms including abdominal pain and distress. Because children with RAP and children with anxiety were characterized by more similarities than differences, we combined these groups and compared them to the control group in the current study.

We hypothesized that HR would be positively correlated with self-reported reactivity to recent (previous 6 months) social stress and negatively correlated with secondary control coping. Second, we hypothesized that HR would be positively correlated with internalizing symptoms as measured by parent- and child-report. Third, we hypothesized that higher HRs and self-reported responses to stress would be associated with higher levels of internalizing symptoms. Fourth, we hypothesized that the combined group of children with RAP and children with anxiety would display higher levels of stress reactivity than healthy controls as measured by HR at baseline and in response to laboratory stress tasks. Last, after exposure to a laboratory analog of social and academic stress, we expected that children with RAP and children with anxiety would report significantly higher pain intensity and display lower pain tolerance than healthy controls in response to the cold pressor task.

## Method

### Participants

Participants included 21 children and adolescents with RAP (9 male, mean age 11.05 years), 21 with an anxiety disorder (11 male, mean age 12.29 years), and 21 healthy controls (9 male, mean age 11.05 years) aged 8–16 years and one parent per child. As described earlier, the children with RAP and children with anxiety were combined to form a simple “clinical” group in analyses ( $n = 42$ ). The mean occupational status, based on the Hollingshead occupational scores that range from 10 to 90 (Hollingshead, 1975) was 43.22 ( $SD = 10.46$ ), equivalent to that of administrators and of medium business owners. The groups did not differ in Hollingshead score. The sample identified as 71% White, 19% African American, 3% Asian, 6% other, and 2% Hispanic, which is representative of the area of from which the sample was drawn. Parent

participants included 58 mothers and 5 fathers (mean age 40.56 years). Of the 87 children approached to participate in the study, 13 were ineligible after the phone screen for the following reasons: the child met criteria for attention-deficit-hyperactivity disorder (ADHD) ( $n = 2$ ), the child was too old to participate ( $n = 1$ ), or the child had a history of but no longer met criteria for RAP or anxiety ( $n = 10$ ). Eleven eligible families were no longer interested in participating after completing the phone screen due to time constraints, difficulty finding transportation to the study center, or difficulty finding childcare for siblings. Families who chose not to participate in the study following the phone screen did not differ from participating families on any demographic characteristics. For all groups, exclusionary criteria included a known chronic health condition, physical handicap, mental retardation, and attention-deficit-hyperactivity disorder (ADHD). ADHD was an exclusionary criterion due to other parts of the study protocol that involved a computer-based attention task not discussed in this article.

Children with RAP were recruited from a tertiary-care gastrointestinal clinic. Children with RAP were eligible if they were diagnosed with functional abdominal pain by a physician and if their symptoms qualified them to fall into any one of the following ROME-II categories: functional dyspepsia, irritable bowel syndrome, functional abdominal pain, abdominal migraine, or aerophagia (Rasquin-Weber et al., 1999) and if the abdominal pain occurred at least three times in the past 3 months and was severe enough to impair functioning or interrupt activities, thus also meeting Apley's (1975) criteria. Abdominal pain diagnoses in the current sample included irritable bowel syndrome ( $n = 5$ ), functional dyspepsia ( $n = 1$ ), and functional abdominal pain ( $n = 18$ ). All of the children in the RAP group (100%) were experiencing abdominal pain with functional disability at least one time per week. As reported in Dufton et al. (2009), 67% of the children in the RAP group currently met criteria for an anxiety disorder, with Generalized Anxiety Disorder being the most prevalent diagnosis.

Children with anxiety disorders (“Anxiety group”) were recruited through an outpatient community mental health center (9.5%) and through email advertisements and flyers distributed in the university medical center and sent to the larger community surrounding the study site (90.5%). Children with anxiety were considered eligible if they were currently in or had received past mental health treatment for an anxiety disorder and if they continued to meet criteria for an anxiety disorder at the time of the study following administration of the Kiddie-Schedule for Affective Disorders and Schizophrenia, Present and Lifetime Version (K-SADS-PL; Kaufman et al., 1997).

As reported in Dufton et al. (2009), all children in the Anxiety group currently met criteria for at least one anxiety disorder, with Generalized Anxiety Disorder being the most prevalent. Nearly 40% of the Anxiety group experienced at least one significantly impairing stomachache a month, and 29% of those children met Apley's criteria for RAP.

Finally, healthy control children were recruited through email advertisements and flyers distributed throughout the community. All control participants were screened for possible anxiety and abdominal pain symptoms over the phone. If the child had received treatment for anxiety or had seen physician for recurrent abdominal pain, the child was considered ineligible for the well group and was re-screened for the RAP or anxiety groups. None of well group participants originally screened for the study were assigned to either of the clinical groups after screening. As reported in Dufton et al. (2009), one child in the well group met criteria for Specific Phobia, and was included in the well group during subsequent data analyses to increase generalizability of findings. Furthermore, none of the healthy control children reported abdominal pain symptoms.

Power calculations were used in order to determine whether we had a sufficient number of participants per group to detect a significant effect in this sample. Power calculations were based on effect sizes from the only published study that has compared children with RAP, children with anxiety, and well children (Dorn et al., 2003). Effect sizes in the Dorn et al. study ranged from medium to large on all between-group comparisons. Power estimates for the proposed study were therefore based on estimates of medium effects (i.e., Cohen's  $d$ 's from .30 to .79) with a power of .85 and an  $\alpha$  coefficient of .05. Based on these anticipated effect sizes, 20 participants were required for each group (children with RAP, children with anxiety, and healthy controls) to detect differences of this magnitude or larger. Twenty-one children per group were enrolled in the study.

### **Procedure**

The study site's institutional review board approved the study protocol. Participating families were reimbursed \$75 for their time and travel expenses. Upon arrival at the research lab, parents and children were presented the study protocol and asked to sign consent and assent forms. With the help of the parent, two electrode sensors were placed on the child's sternum to measure HR. Following this, parents and children were separated. Parents completed questionnaires in a separate room while the child participated in the study protocol. Child participants completed questionnaires upon completion of the study

protocol. The following is a description of the child's study protocol.

#### **Time Point 1: Baseline**

Participants sat quietly for 5 min while baseline HR data were recorded.

#### **Time Point 2: Serial Subtraction**

Starting at 400, children are instructed by the experimenter to subtract by 7 for 2 min. Participants are stopped and instructed to start over at 400 when they make a mistake.

#### **Time Point 3: Social Stress Interview**

The social stress interview is a semi-structured interview that allows the participant to re-experience a specific instance they found stressful (Ewart & Kolodner, 1991). The interviewer leads the participant toward a state of re-experiencing the event through the use of guided imagery, reflective listening, and empathic remarks. This interview has been shown to be a reliable method of eliciting physiological arousal (Ewart & Kolodner). The interview lasted an average of  $6.96 \pm 2.75$  min.

#### **Time Point 4: Cold Pressor**

The Cold Pressor Pain Task (CP) entails the child immersing his or her arm into a cooler of circulating water at  $5^{\circ}\text{C}$  ( $\pm 1^{\circ}\text{C}$ ). The CP apparatus consisted of an insulated cooler filled with 68.14 l of water and an arm hammock. Five kilograms of ice were circulated via a submerged Powerhead 802 water pump. A 4-min exposure time limit was used during the CP. After 4 min the CP ceases to provide any relevant information, as pain responses become confounded with sensations of numbness (Trapanotto et al., 2009). Children were fitted to an adjustable arm hammock to assure that the proportional surface area of exposed arm is consistent between participants (20% of the arm above the elbow). Participants were instructed to (1) immerse their arm in the cold water, (2) place their arm in the hammock, and (3) remain as still as possible during the experiment. The instruction to cope (i.e., "do or think about whatever is needed to be able to keep your arm in the water for as long as you can") was given. Participants used a Numerical Rating Scale (NRS) to report their level of discomfort on a scale from 1 to 10. The NRS has been established as a valid and reliable measure of pain intensity in children, and has been shown to correlate highly with independent observations of children's pain behaviors (Zeltzer, Fanurik, & LeBaron, 1989). The participants rated their pain 20s following immersion of their arm in the CP. Participants were also informed that they could remove their arm at any time.



### Time Point 5: Recovery

Once the child extracted his or her arm from the cold pressor, a “recovery” period commenced. Children were asked to sit still for approximately 5 min following the cold pressor.

## Measures

### HR

HR was measured using BIOPAC physiological data equipment. HR was collected continuously throughout the study protocol. HR was measured by average beats per minute at each study time point. Movement artifacts reduced the number of usable HR data during some study sections (see Table IV).

### Anxiety and Depression Symptoms and Somatic Problems

The Child Behavior Checklist (CBCL) and Youth Self Report (YSR; Achenbach & Rescorla, 2001) were used to assess parent and self-reports of psychological symptoms. The CBCL and YSR assess internalizing (anxiety/depression, somatic complaints), and externalizing (aggression, delinquency) emotional and behavioral problems, as well as social and academic competence. Raw scores were used in the analyses to allow for maximum variance. Reliability and validity of the CBCL and YSR are well established. Only children aged 11 years and above were administered the YSR; 27 children in the clinical group and 10 healthy control children completed the YSR.

### Pain Responses

During the cold pressor task, two pain response measures were taken: pain intensity and pain tolerance. Pain intensity was recorded at 20s as the number reported on the 10-point NRS. Participants who removed their arm before 20s had elapsed rated pain intensity immediately after removing their arm. Pain tolerance was measured as the total time elapsed from the time at which the arm was submerged to the time at which the participant removed their arm.

### Coping and Stress Reactivity

Participants completed the Responses to Stress Questionnaire (RSQ; Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000) concerning the child’s response to social stressors during the previous 6 months. The 57-item RSQ assesses coping mechanisms in reference to age-appropriate social stressors and has been shown to have good reliability and validity, including internal consistency with alphas ranging from .73 to .85 (Connor-Smith et al., 2000). The RSQ measures three types of coping: primary control engagement coping (problem

solving, emotional expression, emotional regulation), secondary control engagement coping (positive thinking, cognitive restructuring, acceptance, distraction), and disengagement coping (avoidance, denial, wishful thinking). It also measures two types of stress responses: involuntary engagement (rumination, intrusive thoughts, emotional arousal, physiological arousal, impulsive action) and involuntary disengagement (cognitive interference, involuntary avoidance, inaction, emotional numbing). The Social Stress version of the RSQ (Connor-Smith et al., 2000) was used in the current study so that participants in each of the three groups could complete the same version of the form given that most children and adolescents experience at least some form of social stress. The RSQ has been used successfully with children under the age of 11 years (e.g., Compas et al., in press; Fear et al., 2009; Jaser et al., 2005).

## Results

No correlations between demographic variables and dependent variables were significant. Pearson correlations were used to assess associations among the dependent variables (HR, self-reported responses to stress, coping, and psychological symptoms). To control for multiple correlations and comparisons, we used a Bonferroni correction to correct for family-wise error (adjusted  $p < .02$ ) for both correlations and group comparisons. Correlations were run separately by group (clinical vs. well). A group  $\times$  time analysis of variance (ANOVA) was used to examine group differences on HR at each of the study time points. Cohen’s  $d$  effect size calculations (1988) were performed for all significant correlations and between-group differences. We used the following rules to interpret the effect size of correlations:  $r$  between 0.1 and 0.23 indicate a small effect, those between 0.24 and 0.36 indicate a medium effect, and those  $\geq 0.37$  indicate a large effect. Cohen’s rules for effect size calculations for the group  $\times$  time ANOVA suggest that effect sizes  $< 0.2$  indicate a negligible effect, those between 0.2 and 0.5 indicate a small effect, those between 0.5 and 0.8 indicate a medium effect, and those  $> 0.8$  are considered large effects.

### Associations Among HR, Self-Reported Stress Reactivity, and Coping

Table I shows the correlations among HR at baseline and in response the experimental tasks, and the subscales of coping and involuntary stress responses on the RSQ. The correlations between HR and RSQ subscales within well/clinical groups are based on sample sizes of 14/32 at baseline, 15/32 during serial subtraction, 15/32 during the

Table I. Correlations Between HR and RSQ Coping and Stress Response Subscales

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. RSQ primary control coping	–	.47**	–.70**	–.52**	–.81**	–.20	–.11	–.09	–.05	–.18
2. RSQ secondary control coping	.08	–	–.56**	–.70**	–.74**	–.21	–.16	–.20	–.04	–.12
3. RSQ disengagement coping	–.30	.00	–	.11	.68	.17	–.12	.04	–.26	.11
4. RSQ involuntary engagement	–.31**	–.75**	–.30	–	.46	.22	.44**	.38	.25	.23
5. RSQ involuntary disengagement	–.55**	–.57**	.06	.28	–	.18	.02	–.03	.00	.05
6. HR baseline	–.12	–.14	–.22	.44**	–.07	–	.69**	.75**	.75**	.88**
7. HR serial subtraction	.23	–.25	–.42	.47**	–.17	.83**	–	.70**	.70**	.69**
8. HR social stress interview	.21	–.22	–.41	.39	–.11	.80**	.87**	–	.83**	.86**
9. HR cold pressor	.38	–.41	–.10	.37	–.18	.40	.52*	.66**	–	.87**
10. HR recovery	.21	–.14	–.44**	.34	–.14	.84**	.83**	.94**	.51**	–

Note: Clinical group correlations are on the lower left; healthy control correlations are on the top right. Measures include the Responses to Stress Questionnaire (RSQ) and heart rate (HR).

\*\* $p < .02$ .

Table II. Correlations Between HR and CBCL/YSR Subscales

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. CBCL anxiety/depression	–	.56**	.92**	.36	.19	.26	.12	.06	.37	.13	.27
2. CBCL somatic complaints	.41**	–	.75**	.28	.26	.38	–.06	.11	.01	–.21	–.09
3. CBCL total internalizing	.83**	.79**	–	.29	.15	.20	–.05	–.02	.14	–.09	.05
4. YSR anxiety/depression	.18	.23	.18	–	.57**	.86**	.10	.17	.17	.06	–.11
5. YSR somatic complaints	–.18	.06	–.03	.57**	–	.76**	.42	.53**	.40	.28	.28
6. YSR total internalizing	.04	.18	.09	.86**	.76**	–	.27	.22	.13	.12	.11
7. HR baseline	.22	.46**	.37	.10	.42	.27	–	.69**	.75**	.75**	.88**
8. HR serial subtraction	.23	.40**	.32	.17	.53**	.22	.83**	–	.70**	.70**	.69**
9. HR social stress interview	.16	.43**	.30	.17	.40	.13	.80**	.87**	–	.83**	.86**
10. HR cold pressor	–.17	.33	–.01	.05	.28	.12	.40	.52*	.66**	–	.87**
11. HR recovery	–.02	.42**	.20	–.11	.58**	.11	.84**	.83**	.94**	.51**	–

Note: Clinical group correlations are on the lower left; healthy control correlations are on the top right. Measures include the Child Behavior Checklist (CBCL), Youth Self Report (YSR) and heart rate (HR).

\*\* $p < .02$ .

social stress interview, 11/23 during the cold pressor, and 15/30 during recovery. Within the clinical group, disengagement coping was significantly negatively correlated with HR during recovery. Self-reported stress reactivity (involuntary engagement; physiological arousal, emotional arousal, intrusive thoughts) was significantly positively correlated with HR during baseline in the clinical group, and during serial subtraction in both groups.

### Associations Among HR and Psychological Symptoms

Table II shows the correlations between psychological symptoms (as measured by the YSR and CBCL) and HR. The correlations between HR and the CBCL subscales within well/clinical groups are based on sample sizes of 15/36 at baseline, 16/37 during serial subtraction, 16/36 during the social stress interview, 12/26 during the cold pressor, and 16/34 during recovery. The correlations

between HR and the YSR subscales within well/clinical groups are based on sample sizes of 7/23 at baseline, 7/23 during serial subtraction, 7/23 during the social stress interview, 6/18 during the cold pressor, and 8/21 during recovery. HR at baseline, during the two stress tasks, and during recovery was significantly positively correlated with CBCL somatic complaints in the clinical group. HR during serial subtraction was significantly positively correlated with YSR somatic complaints in the clinical group. HR during recovery was significantly positively correlated with YSR somatic complaints in both the clinical and control groups.

### Associations of Psychological Symptoms with Self-Reported Stress Reactivity and Coping

Table III shows the correlations between psychological symptoms (as measured by the YSR and CBCL) and subscales of the RSQ. The correlations between the RSQ and

Table III. Correlations Between RSQ Subscales and CBCL/YSR Subscales

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. RSQ primary control	–	.47**	–.70**	–.52**	–.81**	.01	–.17	–.05	.17	.24	.03
2. RSQ secondary control	.08	–	–.56**	–.70**	–.74**	–.05	–.19	–.05	–.57**	–.41	–.66**
3. RSQ disengagement	–.30	.00	–	.11	.68	.04	.16	.07	.16	.05	.35
4. RSQ involuntary engagement	–.31*	–.75**	–.30	–	.46	.11	.14	.09	.34	.13	.32
5. RSQ involuntary disengagement	–.55**	–.57**	.06	.28	–	–.12	.19	–.02	.17	.09	.24
6. CBCL anxiety/depression	–.09	.31	.21	–.20	–.22	–	.56**	.92**	.36	.19	.26
7. CBCL somatic complaints	–.02	.01	–.04	.12	–.12	.41**	–	.75**	.28	.26	.38
8. CBCL total internalizing	–.07	.13	.13	–.05	–.15	.83**	.79**	–	.29	.15	.20
9. YSR anxiety/depression	–.10	–.35	–.04	.44**	.06	.18	.23	.18	–	.57**	.86**
10. YSR somatic complaints	–.06	–.47**	–.30	.48**	.27	–.18	.06	–.03	.57**	–	.76**
11. YSR total internalizing	–.15	–.51**	–.23	.59**	.24	.04	.18	.09	.86**	.76**	–

Note: Clinical group correlations are on the lower left; healthy control correlations are on the top right. Measures include the Responses to Stress Questionnaire (RSQ), Child Behavior Checklist (CBCL) and Youth Self Report (YSR).

\*\* $p < .02$ .

the CBCL subscales within well/clinical groups are based on sample sizes of 20/37. The correlations between the RSQ and the YSR subscales within the well/clinical groups are based on sample sizes of 10/27. Secondary control coping was significantly negatively correlated with the YSR somatic complaints in the clinical group, with YSR anxious/depressed in the control group, and with YSR total internalizing in both groups (see Table III). RSQ involuntary engagement was significantly positively correlated with the YSR anxious/depressed, somatic complaints, and total internalizing subscales in the clinical group.

### HR at Baseline and in Response to Laboratory Stress Tasks

HR means and standard deviations are presented in Table IV. There was a significant main effect for time,  $F(1,37) = 6.73$ ,  $p < .001$ , but no group  $\times$  time interaction. The clinical group displayed significantly higher HRs at baseline  $F(1,49) = 6.03$ ,  $p = .02$ ,  $d = .48$ , and during the cold pressor  $F(1,36) = 7.85$ ,  $p = .008$ ,  $d = .71$ .

### Pain Intensity and Pain Tolerance

The clinical and healthy control groups did not differ on the Pain Scale rating (pain intensity) and total time in the child's arm was immersed in the cold pressor (pain tolerance).

### Discussion

RAP is a highly prevalent childhood pain condition associated with increased healthcare use and functional disability (Campo & Fritsch, 1994; Hyams et al., 1996). Clinicians and researchers have postulated associations between anxiety and RAP in children (e.g., Apley, 1975; Scharff, 1997)

and recent studies have provided empirical support for a strong association between these two disorders (Blanchard & Scharff, 2002; Dorn et al., 2003; Dufton et al., 2009). This study examined stress responses and coping in a clinical sample that included children diagnosed with RAP and children with anxiety (combined into a single "clinical" group), and a healthy control comparison group. A central focus of this study was the role of reactivity to stressful events as a psychophysiological factor in pediatric RAP and anxiety as compared with healthy control children.

This study showed that, in the clinical group, self-reported stress reactivity in response to past social stress was positively correlated with mean HR at two of the five time points examined in this study (baseline and during serial subtraction) and child-reported internalizing symptoms. HR was positively associated with increased self- and parent-reports of somatic symptoms. In the well group, self-reported stress reactivity was also positively associated with mean HR during one of the laboratory stressors (serial subtraction), and HR was positively associated with increased reports of somatic symptoms. These results suggest that HR reactivity may be a general indicator of stress reactivity in children and adolescents. The findings should be interpreted cautiously, however, since the sample size of the well group is reduced compared to the clinical group.

The clinical group had significantly elevated HRs at baseline compared to healthy controls, and their HRs remained higher than the healthy control children during the laboratory-based stressors and during recovery. This pattern of greater sympathetic arousal may be indicative of a decreased threshold in response to stress in this population. This pattern of a high and stable resting HR is similar to that found in children with behavioral

Table IV. HR by Time Point Means, Standard Deviations, and Between-Group Comparisons

Time Period	<i>n</i>	Clinical Mean ( <i>SD</i> )	<i>n</i>	Well Mean ( <i>SD</i> )	<i>F</i> -tests
Baseline	36	88.05 (7.04)	15	82.33 (4.77)	$F(1,49) = 6.03, p = .02^{**}$
Serial subtraction	37	89.72 (9.08)	16	86.98 (7.36)	$F(1,51) = 1.77, p = .19$
Social stress interview	36	89.71 (9.57)	16	87.84 (6.97)	$F(1,50) = 2.40, p = .13$
Cold pressor	26	90.31 (7.82)	12	84.29 (9.16)	$F(1,36) = 7.85, p = .008^{**}$
Recovery	34	87.07 (8.08)	16	83.94 (6.62)	$F(1,48) = 1.38, p = .25$

Note: Clinical group correlations are on the lower left; healthy control correlations are on the top right. Measures include the RSQ and HR.

\*\* $p < .02$ .

inhibition, a temperamental precursor to anxiety disorders (Kagan, Reznick, & Snidman, 1988). It is plausible that this physiological indicator of stress is a marker of and possibly contributes to the high levels of anxiety found in children with RAP (Dufton et al., 2009). Combined with their high scores on self-reported stress reactivity, these data indicate a promising avenue for continued research examining responses to stress in children with RAP and/or anxiety.

This study provides data regarding a multi-method approach to measuring stress reactivity in children. Children reported on their stress reactivity to past social stress and then completed several tasks in the laboratory, one of which directly mimics a social stressor, while their physiological stress reactivity was measured. Despite using HR as a relatively imperfect measure of a child's physiological response to stress, data from the involuntary engagement scale of the social stress version of the RSQ (Connor-Smith et al., 2000), which measures self-reported stress reactivity including physiological and emotional arousal, was positively correlated with HR at all time points in the study. Children's self-report of internalizing symptoms was also correlated with both the RSQ and HR throughout the study. This suggests that self-report measures may be a means to capture physiological responses to stress. Connor-Smith and Compas (2004) similarly found a significant correlation between self-reports of involuntary engagement responses on the social stress version of the RSQ and HR reactivity to a laboratory stress task in a college student sample. The current study provided evidence for a direct relationship between self-reported reactivity to social stress (involuntary engagement subscale of the RSQ) and a direct physiological response (HR) to stress, including social and physical stress, in a sample of children and adolescents.

The present study has several limitations. First, the relatively small sample size may have reduced the ability to detect some between-group effects. Particularly in relation to HR differences, within-group analyses were somewhat underpowered to detect within-group changes in HR

over time. Furthermore, age restrictions of the YSR reduced the number of children self-reporting on internalizing symptoms, which may have led to differences in parent and child-report of somatic symptoms and their relation to HR. Second, only child-report was used to assess coping and automatic responses to stress. Combining child- and parent-report into latent variables can provide meaningful information about coping in children separate from informant effects (Compas et al., 2006). Third, HR change over time is an imperfect measure of physiological responses to stress. Other measures of stress reactivity and recovery, including blood pressure and HR variability, are associated with coping and stress responses in children (e.g., Dorn et al., 2003; Eisenburg, Valiente, & Sulik, 2009; Pusanovova et al., 2009). Focusing on parasympathetic functioning by using measures of HR variability and vagal tone may lead to insights into how children with RAP and children with anxiety recover from stress. Fourth, the self-reported measure of social stress was not designed to exactly replicate the stressors induced in the laboratory, but rather all of the stressors in the study were chosen to represent overlapping and relevant constructs for these children. Future research may consider replicating in the laboratory the exact situations assessed in self-report measures. Lastly, our sample was drawn from a tertiary care gastroenterology clinic (children with RAP). Children with RAP in our study are likely to differ from children in the general population who suffer from RAP or anxiety who have not sought or been referred for medical or psychiatric care. "Berkson's bias" suggests that it is the confluence of problems that initiates patients to seek or be referred for professional care when symptoms arise, increasing the likelihood of comorbid problems in clinical samples (McConaughy & Achenbach, 1994). The comorbidity of RAP and anxiety may be higher in samples presented in this study than would be found in the general population of children with either of these disorders, and as such may bias our results. Future studies would do well to include a comparison group of children with functional gastrointestinal disorders who were not seen in tertiary care, in



addition to a group of children with an organic cause for their stomach pain, in order to control for this bias.

Results from this study indicate that further research examining responses to stress and coping in recurrent episodes of abdominal pain in children is warranted. The number of studies examining biopsychosocial correlates of RAP is growing; however, several questions that could have direct beneficial effects for this population need to be addressed. For example, this study explored the potential biological and psychological underpinnings of RAP in children, including possible autonomic nervous system irregularities that may contribute to both episodes of pain and anxiety in children with RAP. Further research examining stress reactivity, stress recovery, and coping is needed in order to help elucidate these connections, and will provide useful clues into the development and progression of RAP. Future studies examining coping in this population are necessary in order to delineate whether the way in which children with RAP cope with their episodes of abdominal pain, as detailed by Thomsen et al. (2002), Walker, Smith, and Van Slyke (1997), and Compas et al. (2006), is similar to the way in which they cope with other forms of stress. Identification of the ways that children with RAP and/or anxiety disorders cope with common sources of stress (e.g., school achievement stress or peer stress) can subsequently serve as possible targets for intervention.

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