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Role of Anticipatory Anxiety and Anxiety Sensitivity in Children's and Adolescents' Laboratory Pain Responses

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Abstract

Objective—To examine relationships among trait anxiety sensitivity, state task-specific anticipatory anxiety, and laboratory pain responses in healthy children and adolescents.

Methods—Participants (*N*=118, 49.2% female, ages 8-18 years) completed a measure of anxiety sensitivity and rated anticipatory anxiety prior to undergoing thermal, pressure, and cold pain tasks. Linear and logistic regressions were used to test the hypothesis that anxiety sensitivity and anticipatory anxiety would predict incremental variance in pain response after controlling for sex, age, and anxious symptoms.

Results—Anticipatory anxiety accounted for 35-38% of unique variance in pain report across tasks, and 10% of unique variance in thermal tolerance. Anxiety sensitivity was unrelated to pain responses.

Conclusions—Task-specific anxiety is an important predictor of pain report and, in certain cases, pain tolerance. Interventions designed to reduce task-specific anticipatory anxiety may help reduce pain responses in children and adolescents.

Keywords

laboratory pain; anxiety; anxiety sensitivity; children; adolescents

Pain is a common experience among children and adolescents (McGrath et al., 2000; Perquin et al., 2000). A recent epidemiological survey found that 54% of respondents aged 4 to 18 years reported experiencing pain within the previous 3 months, with the most common types of pain being limb pain, headache, and abdominal pain (Perquin et al., 2000). In addition to such pain symptoms, children and adolescents also commonly experience acute pain as a result of injuries, illness, or medical procedures. Current models conceptualize pain as a complex, multidimensional construct, incorporating biological and psychosocial aspects (Gatchel & Turk, 1999). The actual experience of pain is seen as encompassing sensory as well as affective components (Gatchel & Turk, 1999).

Recognition of the affective aspects of the pain experience has led to considerable interest in delineating the relationship between pain and anxiety. In the pediatric literature, the majority of studies to date have focused on the impact of anxiety on pain related to medical procedures.

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The general finding is that of a positive association between anticipatory anxiety and procedural pain. For example, ratings of anticipatory anxiety in 28 children aged 7-17 years were found to predict their postoperative pain ratings (Palermo & Drotar, 1996). Similarly, in a study of 63 pediatric cancer patients, behavioral observations of preprocedural anxiety correlated .80 with observed pain reactions to bone marrow aspiration (Hilgard & LeBaron, 1982).

State-specific ratings of anticipatory anxiety about upcoming procedures are proximal measures that can be conceptualized as indices of perceived aversiveness or threat. It is conceivable that more distal, trait constructs related to anxiety may also influence pain. In the adult literature, the anxiety sensitivity (AS) construct has emerged as an important predictor of pain response. *AS* refers to the tendency to interpret anxiety-related bodily sensations as dangerous (Taylor, 1999). It is considered a relatively stable dispositional or trait construct that has been linked to panic and other anxiety disorders (Taylor, 1999), as well as chronic pain (Asmundson, 1999). Moreover, AS has been found to exacerbate the fear of pain (Asmundson & Taylor, 1996). In healthy adolescents, AS demonstrated a unique relationship to fear of pain, after controlling for pain and anxiety symptoms (Muris, Vlaeyen, & Meesters, 2001).

Several studies have linked AS to laboratory pain reactivity in healthy adults (Keogh & Birkby, 1999; Keogh & Cochran, 2002; Keogh & Mansoor, 2001) and adults with panic disorder (Schmidt & Cook, 1999). On the other hand, Stewart and Pihl (1994) found no relationship between AS and pain ratings in adult women in response to loud noise bursts. The general finding from the positive studies is that for women, high AS is associated with increased pain intensity, but AS shows no relationship with pain threshold or tolerance for either men or women. Notably, the study with panic disorder patients found that AS appeared to have an indirect relationship with pain—that is, AS was not related to pain beyond changes in state anxiety during the pain task. The authors suggest that AS may enhance pain intensity when patients are anxious (Schmidt & Cook, 1999). Thus, high AS is seen as increasing patients' vulnerability to experiencing anxiety, which then leads to increased pain (Schmidt & Cook, 1999). It is not known whether these relationships hold in nonclinical populations, since Keogh and colleagues did not include measures of state anxiety. Thus, it is possible that increased pain report in women with high AS may have been due to increased anxiety in response to pain (Keogh & Cochran, 2002).

To the authors' knowledge, no comparable laboratory studies have been conducted in younger populations, hence little is known about the potential influence of trait AS and state-specific anxiety on pain response. Prior research using "real world" medical procedures was subject to inherent variations in stimulus intensity and/or duration that may have obscured the impact of such individual difference variables. Also, prior studies in the pediatric literature did not distinguish between state and dispositional measures of anxiety in relation to pain. If AS demonstrates strong links to pain response, then interventions geared toward addressing fear of anxiety symptoms may prove useful in younger populations. Thus, in this study we examined the influence of trait AS and state task-specific anticipatory anxiety on pain response to three laboratory tasks (cold pressor, pressure, and thermal pain) in a healthy, non-clinic-based sample of children and adolescents. We hypothesized that AS would predict incremental variance in pain response after controlling for demographic variables (age, sex) and anxiety symptoms. We also hypothesized that task-specific anticipatory anxiety would predict further incremental variance in pain response after controlling for these variables.

Method

Participants

Participants were 118 children and adolescents (58 female, 49.2%), with a mean age of 12.6 years (*SD* = 3.16, range = 8-18). Participants were part of a larger study examining the influence

of puberty on pain response, and the broad age range was designed to include the oldest age at which children were expected to be prepubertal, through adolescence. The ethnic composition of the sample was 43.2% white, 18.6% Hispanic, 12.7% African American, 11.9% Asian American, and 12.7% other. The majority (over 75%) were of middle to upper socioeconomic status (Hollingshead, 1975). Participants were recruited from a major urban area through mass mailing, posted advertisements, and classroom presentations. Initial eligibility was confirmed by telephone: Potential participants received a verbal description of the study, and those reporting ongoing acute or chronic illness or use of prescription medications that would affect study measures were excluded. Once eligibility was confirmed and verbal consent was obtained from a parent via telephone, written informed parental consent and child/adolescent assent forms were mailed to participants to review and sign, and were collected on the day of the laboratory session. Upon arrival at the laboratory, study procedures and participants' rights were discussed with participants and parents. The University of California, Los Angeles (UCLA), institutional review board (IRB) as well as the IRBs for recruitment sites, including the Los Angeles Unified School District, approved all recruitment and study procedures. Participants received a $30 video store gift certificate and a T-shirt for their participation. The honorarium was approved by the UCLA IRB and appropriately reflected the time and effort involved with participation (approximately 5-6 hours total, including travel time).

For the larger study from which the current sample was drawn, 489 individuals were screened for eligibility by telephone; 17 children (3.5% of those screened) were excluded. Of the 472 invited to participate, 228 (48%) declined participation due to lack of interest or time. In total, 244 healthy children (124 female) and their parents provided written informed assent and consent, respectively; of these, 4 did not complete the protocol in its entirety: 1 felt uncomfortable being attached to the physiological sensors, while the other 3 refused to do the lab pain tasks due to lack of time or interest. Of the 118 participants in the present study, 5 had missing data (i.e., incomplete responses to the questionnaires) and were excluded; the final sample consisted of 113 children and adolescents.

Procedure

On the day of the laboratory session, participants and their parents were greeted by an experimenter and then escorted to separate rooms. There was no contact between them until after the session was finished. Participants first completed questionnaires administered by an experimenter in a quiet room adjacent to the laboratory. They were then led into the laboratory, where their height and weight were recorded, medication use for that day was assessed, and leads for physiological recording were attached. (Physiological data were continuously recorded during the laboratory session but will be presented in a separate report.) Participants were instructed in the use of the visual analog scale (VAS) for rating pain and anticipatory anxiety (described below). The VAS is brief, easily understood, and sensitive to changes in pain, has excellent psychometric properties, and can be used by the age of 5 years to rate pain intensity (McGrath & Gillespie, 2001). Prior research used the VAS to rate anticipatory anxiety and pain in children (Palermo & Drotar, 1996). Three practice ratings were completed to ensure that participants understood the VAS. The practice trials asked: (1) "How afraid or nervous would you be right before taking an important exam or test?" (2) "How much would it bother you to eat your favorite dessert?" (3) "How afraid, nervous, or worried do you feel right now?" The instructions and practice trials were repeated until participants fully understood the VAS. Participants were then instructed about and exposed to the three pain tasks, counterbalanced across participants. All tasks were extensively piloted on volunteers in the targeted age range to ensure safety and acceptability and to determine the lowest level of stimulation that would allow sufficient variation in responding.

Cold Pressor Task (CPT)—Participants underwent two trials in 10 °C water using a commercial ice chest measuring 38 cm wide, 71 cm long, and 35 cm deep. A plastic mesh screen separated crushed ice from a plastic large-hole mesh armrest in the cold water. Water was circulated through the ice by a pump to prevent local warming about the hand. In the first trial, participants placed the nondominant hand in cold water to a depth of 2 in. above the wrist and held it there for as long as they could, with an uninformed ceiling period of 3 min. In Trial 2, participants were instructed to keep the dominant hand in the water for 1 min. Only data from the first trial were included in these analyses.

Pressure Task—The Ugo Basile Analgesy-Meter 37215, similar to the Forgione/Barber pressure stimulator (Forgione & Barber, 1971), was used to administer focal pressure through a Lucite point approximately 1.5 mm in diameter to the second dorsal phalanx of the middle finger or index finger of each hand. Four trials at two levels of pressure (322.5 g and 465 g) were run with an uninformed ceiling of 3 min. A comparable device has been used in healthy and clinical pediatric samples (aged 5 to 17 years) without adverse effects (Gil et al., 1997; Walco, Dampier, Hartstein, Djordjevic, & Miller, 1990).

Thermal Task—The Ugo Basile 7360 Unit was used to administer a total of four trials of two infrared intensities (15, 20) of radiant heat 2 in. proximal to the wrist and 3 in. distal to the elbow on both volar forearms, with an uninformed ceiling of 20 sec. Thermal pain tolerance was electronically measured with an accuracy of 0.1 sec. A similar task has been used in a sample aged 6 to 17 years without adverse effects (Meier, Berde, DiCanzio, Zurakowski, & Sethna, 2001).

After each trial, there was a 1-min interval. For the thermal and pressure tasks, the presentation order (setting, site) was counterbalanced across participants. Before the start of each trial, subjects were informed that they would experience moderate sensation that mighteventually be perceived as pain. Participants were instructed to continue with the task for as long as they could and to withdraw from the apparatus if it became too uncomfortable/painful.

Measures

Questionnaires

The Childhood Anxiety Sensitivity Index: (CASI) (Silverman, Fleisig, Rabian, & Peterson, 1991) is an 18-item scale that measures the tendency to view anxiety-related bodily sensations as dangerous (e.g., “It scares me when my heart beats fast”). Items are scored on a 3-point scale (*none*, *some*, *a lot*), and total scores are calculated by summing all items. The CASI has demonstrated high internal consistency ($\alpha = .87$) and adequate test-retest reliability (range = .62-.78 over 2 weeks) (Silverman et al., 1991). The CASI correlates well with measures of trait anxiety ($r = .55$-$.69$) but also accounts for variance in fear not attributable to trait anxiety measures (Weems, Hammond-Laurence, Silverman, & Ginsburg, 1998).

The Multidimensional Anxiety Scale for Children: (MASC) (March, 1997) is a 39-item measure of anxiety symptoms consisting of four subscales representing empirically derived domains of childhood anxiety: physical symptoms, social anxiety, harm avoidance, and separation anxiety. Items are scored on a 4-point scale (*never*, *almost never*, *sometimes*, *often*); total and subscale scores are calculated by summing relevant items. The MASC has shown high internal consistency ($\alpha = .88$ for total score) and good test-retest reliability (March, 1997). In contrast to the more established Revised Manifest Child Anxiety Scale (Reynolds & Richmond, 1978), the MASC has demonstrated adequate divergent validity with scales for depression and externalizing symptoms (March, 1997). The MASC also assesses all currently recognized symptom domains of anxiety (March, 1997), unlike the more traditional State-Trait Anxiety Inventory for Children (Spielberger, 1973).

Pain Task Measures

Anticipatory Anxiety: Ratings of anticipatory anxiety were obtained immediately prior to each trial. Participants used a vertical sliding VAS, anchored with 0 at the bottom indicating the least amount and 10 at the top indicating the greatest amount, in response to the instruction to rate "how nervous, afraid, or worried" they were about the upcoming task. The scale also had color cues, graded from white at the bottom to dark red at the top, as well as a neutral face at the bottom and a face showing a negative expression at the top.

Pain Ratings: Immediately after each trial, participants were asked to rate the level of pain experienced during the task using the same VAS as described above. However, this time for each task, participants were asked, "at its worst," how much pain they felt.

Pain Tolerance: Pain tolerance was defined as time in seconds elapsed from the onset of the pain stimulus to participants' withdrawal from the stimulus.

Results

Statistical Analyses

For the thermal and pressure tasks, data for tolerance and ratings of anticipatory anxiety and pain were highly correlated across the four trials (r = .50-.87, $p < .001$); these data were averaged across trials. Order effects for the three pain tasks were tested; none were found. Questionnaire and pain task data were initially tested for sex differences using a series of independent *t*-tests. Pooled-variance t-tests were employed if Levene's tests indicated unequal variance across groups. Bivariate correlations among the variables were examined, controlling for sex and age. For multivariate analyses of thermal and pressure data, sequential multiple linear regression was used to evaluate the relationship between the independent variables (questionnaire scores and anticipatory anxiety) and dependent variables (pain ratings and tolerance), controlling for sex (boys and girls coded as 1 and 0, respectively) and age. The demographic variables were entered in the first step of the regression analyses, followed by the MASC total score (Step 2), the CASI (Step 3), and anticipatory anxiety ratings (Step 4). Separate regressions were run for pain ratings and for tolerance.

Residuals were examined for violation of assumptions and outliers. The CPT data were bimodally distributed, such that assumptions for linear regression were substantially violated. For CPT tolerance, the distribution indicated two distinct groups: participants who tolerated the trial for less than 70 sec (low tolerance group) (n = 89, 78.8%) and those who tolerated the trial for 70 or more seconds (high tolerance group). For CPT pain ratings, the distribution also indicated two groups: participants whose VAS ratings were less than 4.5 (low pain group) (n = 70, 61.9%) and those whose ratings were 4.5 or above (high pain group). Sequential logistic regressions were used with the same predictors entered in the same order as above to examine group membership in the CPT tolerance and pain ratings groups. One participant with missing tolerance data was eliminated in the analyses of CPT data.

Preliminary Analyses—Questionnaire scores did not differ by sex. Although girls scored higher than boys on both the CASI and the MASC, these differences did not reach statistical significance. Whereas CASI scores were not correlated with age (r = -.03, *ns*), MASC total scores were significantly inversely correlated with age (r = -.19, $p < .05$). Means for the CASI, total MASC, and MASC subscales did not differ by ethnicity. The CASI and MASC total scores were significantly correlated (r = .57, $p < .001$); and the CASI was also significantly correlated with all MASC subscales (r = .27-.46, $p < .001$). For anticipatory anxiety, girls (M = 2.58, SD = 2.38) had higher ratings compared with boys (M = 1.79, SD = 1.78) on the CPT only, $t(97.9) = 1.99$, $p < .05$; there were no significant differences in anticipatory anxiety

by ethnicity. Analyses of the pain task data revealed two significant sex differences: for pressure tolerance, boys (M = 49.2, SD = 47.3) had significantly higher tolerance than girls (M = 32.6, SD = 40.5), $t(108.9) = -2.00$, $p < .05$; for CPT pain ratings, males were more likely to be in the low pain group compared with females, $\chi^2(1) = 3.86$, $p < .05$. There were no differences in pain task data based on ethnicity. For all three tasks, pain ratings were inversely correlated with age (r = -.20 to -.31, $p < .05$). For the thermal and pressure tasks, but not the CPT, anticipatory anxiety ratings were inversely correlated with age (r = -.26 to -.32, $p < .01$). Tolerance was positively correlated with age for both thermal and pressure tasks, but not for the CPT (r = .29-.54, $p < .01$). Chi-square analysis indicated that the CPT tolerance and pain ratings groups did not substantially overlap.

Bivariate Analyses—Table I shows the bivariate correlations (controlling for sex and age) among the questionnaires, anticipatory anxiety ratings, and pain task data. The CASI and the MASC total, social, and separation anxiety subscales were significantly correlated with pain ratings for the thermal task. The table also shows that anticipatory anxiety ratings were highly correlated with pain ratings for the thermal and pressure tasks, and inversely correlated with tolerance for the thermal task. For the CPT, bivariate correlations were calculated for the pain ratings and tolerance groups separately. As shown in Table I, the CASI was related to pain ratings in the high pain group but evidenced no other associations, and the MASC total and physical symptoms subscales were related to pain ratings in the low tolerance group. CPT anticipatory anxiety ratings were significantly related to pain ratings in the low pain and low tolerance groups.

Additional analyses (data not shown) revealed that the questionnaire scores were, in the main, correlated with anticipatory anxiety ratings. The MASC total and CASI were significantly correlated with anticipatory anxiety for the thermal and pressure tasks (r = .21-.28, $p < .05$). For the CPT, the MASC total was significantly correlated with tolerance in the high tolerance group (r = .46, $p < .05$), and the CASI was significantly correlated with pain ratings in the low pain group (r = .25, $p < .05$).

Multivariate Analyses—Results for the sequential multiple linear regressions are shown in Table II. For the thermal task, after the entry of sex and age (Step 1), addition of the MASC (Step 2) resulted in a significant, incremental increase in the prediction in pain ratings, explaining an additional 5% of the variance (see Table II). Addition of the CASI (Step 3) did not improve model prediction. Finally, addition of anticipatory anxiety ratings (Step 4) significantly improved prediction of pain ratings, accounting for an additional 35% of the variance. The complete model including all predictors explained 55% (53% adjusted) of the variance in pain ratings. For tolerance, after controlling for sex and age, addition of anticipatory anxiety ratings in the final step predicted significant, incremental variance in thermal tolerance, explaining 10% of additional variance. Neither questionnaire measure reliably improved model prediction. The full model containing all predictors accounted for 43% (41% adjusted) of the variance in tolerance.

For the pressure task, after entry of sex and age in the first step, addition of anticipatory anxiety ratings in the final step resulted in a significant incremental increase in the prediction of pain ratings, accounting for an additional 38% of the variance (see Table II). Neither questionnaire measure significantly improved model prediction. The complete model with all predictors accounted for 48% (46% adjusted) of the variance in pain ratings. For tolerance, only sex and age (Step 1) emerged as significant predictors. Together, sex and age accounted for 14% of the variance in tolerance; the full model including all predictors explained 18% (14% adjusted) of the variance in tolerance.

Results of the logistic regression for the CPT pain ratings groups are presented in Table III. There was a good model fit (discrimination among groups), $\chi^2(8, N = 110) = 6.94$, $p = .54$, log likelihood = 125.45; the overall model explained 18% of the variance in group membership (Cox & Snell R^2). As shown in the table, inclusion of the MASC at Step 2 reliably improved model fit. The significant odds ratio (OR) in Table III indicates that a 1-unit increase in the MASC increased the likelihood of being in the high pain group by 1.05 units. Inclusion of anticipatory anxiety in the final step also reliably improved model fit. The significant OR shown in Table III indicates that as anticipatory anxiety increased by 1.00 unit, the likelihood of being in the high pain group increased by 1.44 units. Overall classification rate for the model with all predictors included was 71.4%, with 85.7% of low pain and 47.6% of high pain participants correctly classified. Results of the logistic regression on the CPT tolerance group indicated reasonable model fit when all predictors were entered, $\chi^2(8, N = 110) = 3.02$, $p = .93$, log likelihood = 107.26. However, none of the individual predictors reliably contributed to discrimination between the groups.

Discussion

We hypothesized that AS and task-specific anticipatory anxiety would predict laboratory-induced pain responses in a sample of healthy children and adolescents, after controlling for sex, age, and anxiety symptoms. Our hypothesis was partially confirmed in that anticipatory anxiety significantly predicted incremental variance in pain intensity for all three tasks. Anticipatory anxiety accounted for 35-38% of the variance in pain intensity over and above that explained by the other variables, suggesting that it is an important predictor of self-reported pain. Although our models were less successful in explaining tolerance, anticipatory anxiety predicted 10% of additional, unique variance in thermal tolerance, after all other variables were taken into account. Contrary to our hypothesis, AS did not predict incremental variance in pain response. In fact, AS was largely unrelated to pain responses, with the exception of modest correlations with thermal and cold pressor pain intensity (see Table I). In multivariate analyses, these relationships were no longer significant after controlling for anxious symptomatology.

Our findings are consistent with existing studies reporting positive associations between anticipatory anxiety and procedural pain in children (Hilgard & LeBaron, 1982; Palermo & Drotar, 1996). As noted above, we found that anticipatory anxiety showed stronger associations with pain intensity than with pain tolerance. Possible explanations include shared method variance (i.e., use of the VAS for both anxiety and pain ratings) and the notion that anxiety may be linked primarily to pain report, rather than behavioral expression of pain. Previous studies have found discordance between pain intensity and pain tolerance in laboratory studies with younger samples (Fanurik, Zeltzer, Roberts, & Blount, 1993; Tsao, Fanurik, & Zeltzer, 2003), suggesting that these response systems are influenced by different factors. In accord, task-based interventions focused on increasing tolerance have led to immediate and long-term improvements in children's ability to endure pain but without affecting the degree of subjective discomfort (Fanurik et al., 1993; Tsao et al., 2003).

Our null findings for AS agree with Stewart and Pihl (1994), who found that AS did not impact pain ratings in response to aversive noise bursts in healthy adult women. However, our findings contradict those of Keogh and colleagues (Keogh & Birkby, 1999; Keogh & Cochran, 2002; Keogh & Mansoor, 2001), who reported that high AS, relative to low AS, was linked with increased pain report in healthy women (but not men). In all but one of these studies, participants were selected based on AS scores, and it may be that the range of responses in our unselected sample did not allow for sufficient differentiation among high and low AS participants. Another possibility is that high AS participants in the Keogh studies who reported increased pain may have simply been responding to the pain in a more anxious way (Keogh & Cochran, 2002). Nevertheless, it is conceivable that the relationship between AS and pain

response found in adults does not hold in younger samples. It may be that this association in girls emerges only at late stages of pubertal development, at which point their responses would be expected to mirror those of adult women. Our results are more in line with Schmidt and Cook (1999), who found that AS is linked to increased pain report via heightened anxiety in response to the cold pressor. These authors suggested that AS may increase vulnerability to experiencing anxiety, which then leads to increased pain (Schmidt & Cook, 1999). In agreement, we found that AS was significantly related to anticipatory anxiety for the thermal and pressure tasks, although the magnitude of the associations was modest.

Notably, our measure of anxious symptomatology predicted significant variance in pain report for the thermal and cold pressor tasks, after controlling for sex and age. These findings are consistent with reports indicating that pain symptoms are associated with symptoms of anxiety in adult panic disorder patients (Schmidt, Santiago, Trakowski, & Kendren, 2002), as well as studies showing that high trait anxiety is linked to increased laboratory pain ratings (James & Hardardottir, 2002). In adult clinical populations, prior investigations have documented high rates of comorbidity between chronic pain and anxiety disorders (Asmundson & Taylor, 1996). The overlap in these disorders remains understudied in younger populations and warrants further attention.

It is noteworthy that use of experimental pain methods in children has been criticized for ethical concerns regarding the induction of pain in such populations, as well as limited generalizability (McGrath, 1993). While such ethical concerns are understandable, all of our procedures were approved by multiple IRBs and were piloted to ensure safety/acceptability. Regarding limited external validity, laboratory studies have frequently been used in the adult literature to investigate questions concerning clinical pain (Edens & Gil, 1995). Their reproducibility allows examination of important determinants of pain response, as well as intervention effects, without confounding variables (e.g., variations in intensity/duration) inherent to clinical and procedural pain. Because the laboratory session is a novel experience for participants, such studies are less influenced by participants' past history with, and the meanings ascribed to, specific pain stimuli, which have been found to impact children's pain response to medical procedures (Chen, Zeltzer, Craske, & Katz, 1999). Finally, laboratory pain response has been shown to predict child/adolescent functional impairment, as indexed by school absences (Tsao, Glover, Bursch, Ifekwunigwe, & Zeltzer, 2002), suggesting that laboratory pain tasks may have real-world application in helping to identify vulnerable populations. These findings also suggest that laboratory pain studies may assist in identifying vulnerability factors that might contribute to the eventual development of chronic pain, although the utility of laboratory studies in this regard has not yet been tested.

Limitations of our study should be mentioned. As discussed above, the strong association between pain intensity and anticipatory anxiety may be due to the fact that they were both assessed using the VAS. It should also be emphasized that our study does not demonstrate that intervening with anticipatory anxiety actually results in changes in pain ratings. In addition, we did not formally screen for anxiety disorders, so it is not known what portion of the sample may have met criteria for an anxiety disorder. However, all participants were attending school and were not taking psychotropic medications. Although we included age as a control variable in our analyses, there was a broad age range in our sample, and it is conceivable that our findings may have differed in older samples with a more restricted age range. It is possible that the relationship between AS and pain found in adults is evident only in older adolescents and additional studies in this population are warranted. Finally, we did not examine which factors were most predictive of task-specific anticipatory anxiety. Muris et al. (2001) reported that AS is an important predictor of fear of pain in adolescents. Future studies may address the extent to which AS is uniquely related to pain taskspecific anticipatory anxiety, compared with the more general construct of fear of pain.

One clinical implication of our findings is that interventions designed to target anticipatory anxiety may have beneficial effects on pain responses in children and adolescents. Prior research has shown that hypnosis initiated just prior to medical procedures (Zeltzer & LeBaron, 1982) achieved reductions in acute pain responses. In an uncontrolled study in our clinic, we found that a combined complementary and alternative medicine treatment package incorporating acupuncture and hypnosis resulted in significant reductions in pain for chronic pain patients aged 6-18 years (Zeltzer et al., 2002). Anxiety about being penetrated with needles is cited as a common fear among children, and clinicians often hesitate to recommend acupuncture for this reason. However, we found acupuncture to be highly acceptable, following sufficient education and hypnosis to reduce anticipatory anxiety. Thus, anxiety-reduction techniques may be useful for increasing the acceptability of invasive treatment procedures in chronic pediatric pain.

In sum, our findings suggest that in healthy children and adolescents, state-specific anxiety in anticipation of pain is an important predictor of pain report, and in certain cases pain tolerance. Anticipatory anxiety demonstrated a unique relationship to pain response, even after taking into account sex, age, and anxious symptomatology. Contrary to expectation, AS showed only weak associations with laboratory pain reactivity. Thus, a proximal measure of the perceived aversiveness or threat value of pain was more strongly linked to pain response than a distal measure of fear of anxiety symptoms. However, future studies should continue to examine the possible role of AS in pediatric pain given the limitations of the present study, as well as prior evidence of significant associations between AS and laboratory pain response in adults. One possibility is that AS may be a vulnerability factor that predisposes certain high-risk populations to chronic pain syndromes, as has been found for panic disorder (Weems, Hayward, Killen, & Taylor, 2002). Longitudinal studies are needed to examine this possibility with respect to the development of chronic pain. Increased knowledge of how state and trait factors related to anxiety influence pain response may therefore lead to the development of more effective interventions for pain in children and adolescents.

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Table I

Bivariate Correlations (Controlling for Sex and Age) Among Anxiety Questionnaires, Anticipatory Anxiety Ratings, and Pain Task Data

Pain Task Data	MASC Total	MASC Physical Symptoms	MASC Social Anxiety	MASC Harm Avoidance	MASC Separation Anxiety	CASI	Anticipatory Anxiety Ratings
Thermal							
Pain	.25**	.18	.20*	.05	.20*	.19*	.68**
Tolerance	-.02	-.04	-.02	.01	.01	.11	-.34**
Pressure							
Pain	.12	.07	.12	.05	.12	.12	.63**
Tolerance	-.11	-.07	-.07	-.12	-.14	-.01	-.16
CPT high pain (*n* = 43)							
Pain	.10	.14	-.01	.19	-.01	.32*	.05
Tolerance	-.14	.13	-.08	-.14	-.04	-.09	-.14
CPT low pain (*n* = 70)							
Pain	.17	.22	.07	.19	.06	.14	.33**
Tolerance	-.09	-.07	-.07	-.08	-.06	.07	-.19
CPT low tolerance (*n* = 89)							
Pain	.22*	.21*	.19	.14	.05	.14	.33**
Tolerance	-.01	-.03	.01	-.04	-.07	.02	-.21
CPT high tolerance (*n* = 23)							
Pain	.23	.27	.15	.12	.18	.04	.41
Tolerance	-.05	.08	-.20	.09	-.05	.22	-.07

MASC = Multidimensional Anxiety Scale for Children; CASI = Childhood Anxiety Sensitivity Index; CPT = cold pressor task. Pain = pain ratings (0-10); tolerance = tolerance in seconds.

* $p < .05$;

** $p < .01$.

Table II

Sequential Multiple Regression of Sex, Age, Anxiety Questionnaires, and Anticipatory Anxiety Ratings on Thermal and Pressure Pain Response

Step	Variables Entered	β	Model R^2	Change in R^2
Mean thermal pain (DV)				
1	Sex	-.02		
	Age	-.18	.14	.14**
2	MASC	.11	.19	.05*
3	CASI	-.05	.20	.01
4	Anxiety	.65	.55	.35**
Mean thermal tolerance (DV)				
1	Sex	.22		
	Age	.47	.32	.32**
2	MASC	-.07	.32	.00
3	CASI	.15	.34	.02
4	Anxiety	-.34	.43	.10**
Mean pressure pain (DV)				
1	Sex	-.11		
	Age	-.10	.09	.09**
2	MASC	-.04	.10	.01
3	CASI	-.06	.10	.01
4	Anxiety	.68	.48	.38**

β = standardized regression coefficient; model R^2 = coefficient of determination (goodness of fit) for overall regression model after entry of each independent variable; change in R^2 = incremental contribution of an independent variable to R^2 in the total set of independent variables; DV = dependent variable; MASC = Multidimensional Anxiety Scale for Children (total score); CASI = Childhood Anxiety Sensitivity Index.

For sex, boys and girls were coded as 1 and 0, respectively. Pain = pain ratings (0-10); tolerance = tolerance in seconds; anxiety = anticipatory anxiety ratings (0-10).

* $p < .05$;

** $p < .01$.

Table III

Sequential Logistic Regression of Sex, Age, Anxiety Questionnaires, and Anticipatory Anxiety Ratings on Cold Pressor Task Pain Group

Predictor Variable	β	Odds Ratio	95% CI	χ^2 to Remove	*df*
Sex	.14	1.15	0.74-1.80		
Age	.18	1.19	1.03-1.38	6.39*	2
MASC	.05	1.05	1.01-1.09	10.62*	3
CASI	.09	0.92	0.83-1.01	11.99	4
Anxiety	.36	1.44	1.13-1.83	22.74**	5

β = standardized regression coefficient; χ^2 to remove = improvement in model fit when predictor is removed; MASC = Multidimensional Anxiety Scale for Children (total score); CASI = Childhood Anxiety Sensitivity Index.For sex, boys and girls were coded as 1 and 0, respectively; anxiety = anticipatory anxiety ratings (0-10).

* $p < .05$;

** $p < .01$.