Unravelling the Relationship Between Parent and Child PTSD and Pediatric Chronic Pain: the Mediating Role of Pain Catastrophizing

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Alexandra Neville, Sabine Soltani, Maria Pavlova, and Melanie Noel

Department of Psychology, University of Calgary and Alberta Children's Hospital Research Institute, Calgary, Alberta, Canada.

Abstract: **Clinically elevated rates of post-traumatic stress disorder (PTSD) symptoms are found among many youth with chronic pain and their parents and are linked to worse child pain outcomes. Conceptual models of mutual maintenance in pediatric PTSD and chronic pain posit that child and parent pain catastrophizing are key mechanisms underlying this co-occurrence. To our knowledge, the current study is the first to examine child and parent pain catastrophizing as potential mediators in the child PTSD-child pain and parent PTSD-child pain relationships among a cohort of youth with chronic pain. One hundred two children (72.5% female, mean age = 13.5 years), recruited from a tertiary level chronic pain program, and 1 of their parents participated. At intake, parents completed psychometrically sound self-report measures of PTSD symptoms and catastrophizing about child pain. Children completed self-report measures of PTSD symptoms, pain catastrophizing, pain interference, and pain intensity. Findings revealed that relationships between child PTSD and child pain as well as parent PTSD and child pain were mediated by child (but not parent) pain catastrophizing. This suggests that children's catastrophic thinking about pain may explain how child and parent PTSD symptoms influence children's experience of chronic pain and is a potential target in family-based interventions to improve pain and mental health outcomes.**

Perspective: ***Consistent with conceptual models of co-occurring PTSD and chronic pain, children's catastrophic thinking about child pain mediated relationships between parent and child PTSD symptoms and child chronic pain outcomes. Child pain catastrophizing may be a fruitful target in interventions to improve children's chronic pain and mental health outcomes.***

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P ediatric chronic pain is prevalent among youth,[34] associated with high economic burden,[27] and has a profound effect on the entire family.[44,45] Chronic pain has been shown to be highly comorbid with post-traumatic stress disorder (PTSD) in adults[3,7,43] and recently this co-occurrence has been investigated in youth.[42]

Exposure to early life trauma[13] has been associated with the development of pain-related conditions later in life[50,52] and recent epidemiological evidence suggests that adolescent chronic pain is linked to greater risk for lifetime diagnoses of anxiety disorders (including PTSD) reported in adulthood.[40]

Clinically elevated PTSD symptoms have been reported among youth with chronic pain (32%) and their parents (20%) compared with pain-free peers (8%) and their parents (1%).[42] Among youth with chronic pain, higher levels of PTSD symptoms were related to higher pain intensity and pain interference.[42] Similarly, among youth with chronic pain, higher levels of parent PTSD symptoms were related to higher child-reported pain intensity.[42] It has been posited that these PTSD-pain relationships are influenced by parent and child cognitions (eg, pain catastrophizing); however, empirical research has not yet examined specific mechanisms underlying the

relationships between parent and child PTSD symptoms and child chronic pain that may explain why this co-occurrence exists.

Two recently proposed conceptual frameworks highlight factors that may underlie the co-occurrence of PTSD and chronic pain symptoms in youth, including cognitive processes and parent influences.[30,37] Specifically, child and parent pain catastrophizing were proposed as individual and interpersonal mechanisms through which child and parent PTSD symptoms may influence children's chronic pain outcomes.[30] Child and parent pain catastrophizing (ie, the tendency to magnify and ruminate about the threat value, and feel helpless in the face, of child pain) are robust predictors of worse child pain outcomes,[15,26,59] and are closely tied to each other.[36] Pain catastrophizing may underlie the PTSD-pain relationship due to amplification of threat appraisals and fueling of avoidance. Excessive negative appraisals of a traumatic event and/or its sequelae have been implicated in cognitive models of persistent PTSD, such that they may produce a sense of current threat and lead to maladaptive cognitive processing, such as selective attention to threat and rumination.[20] PTSD symptoms of hyperarousal, hypervigilance, and exaggerated negative beliefs may also exacerbate pain symptoms by focusing attention on threatening appraisals (ie, rumination and magnification) of the pain, and increasing feelings of helplessness.

Re-experiencing symptoms and intrusive thoughts, hallmark symptoms of PTSD, and catastrophic thinking also demand cognitive resources that may reduce one's ability to engage in adaptive coping with pain.[54] For example, child PTSD symptoms may influence parent catastrophic thinking about child pain, through observable behaviors that indicate the child's distress, hypervigilance, fear, and avoidance. Moreover, parents' own PTSD symptoms may lead them to interpret their child's pain symptoms as threatening (influencing parent catastrophizing), which could manifest in their affective and behavioral responses to their child's pain (influencing child catastrophizing). This could manifest through parental behavioral responses (eg, protectiveness) that draw children's attention to symptoms and amplify children's catastrophic thinking about pain.[17]

Despite being posited as mechanisms underlying the relationship between PTSD symptoms and child chronic pain outcomes, research has not yet examined the role of child and parent pain catastrophizing in this co-occurrence. To our knowledge, this study is the first to examine the roles of children's and parents' catastrophic thinking about child pain in the relationships between child and parent PTSD symptoms and children's chronic pain symptoms among a cohort of youth with chronic pain. Consistent with the recently proposed pediatric model of co-occurring PTSD and chronic pain,[30] we hypothesized that 1) higher levels of child and parent PTSD symptoms would be associated with increased child pain intensity and interference, and 2) the relationships between child PTSD and child pain as well as parent PTSD and child pain would be mediated by child as well as parent pain catastrophizing.

Methods

Participants and Setting

One hundred eighty-two child-parent dyads were invited to participate in the current study. Of those, 19 declined participation. One hundred two child-parent dyads completed at least 80% of each questionnaire and were included in analyses. Youth and one of their parents were invited to participate either via telephone or e-mail as part of their initial orientation to a tertiary level chronic pain program, before receiving treatment. Youth were eligible if they were between 8 and 18 years of age and were referred to a chronic pain program for pain assessment and/or treatment. Youth and parents who did not speak English and/or were diagnosed with a developmental disorder were excluded from the study.

Data from 102 children and adolescents (72.5% female, mean age = 13.5 years [SD = 4.2], range = 8–18 years) and their parents (93.1% mothers) were included in the analyses. Youth were enrolled in abdominal pain (.9%), complex pain (42.2%), or headache (56.9%) clinics. Sociodemographic information (ie, sex, age, ethnicity, household annual income) are presented in Table 1. Descriptive statistics for parent and child variables are shown in Table 2. Nearly three-quarters (71.6%) of the youth in the sample reported pain in multiple locations and 28.4% of youth reported pain in 1 location (58.6% reported headache, 10.3% reported abdominal pain). The average pain intensity level in the past week was 5.5 of 10 (SD = 2.1). On average, youth reported pain duration of 3.0 years (SD = 2.8); 38.2% of youth reported pain as being "always present." Most of the sample (85%) reported that this was the first time their child had attended a specialist pain service.

Table 1. Sociodemographic Characteristics of the Sample (N = 102)

SOCIODEMOGRAPHIC CHARACTERISTIC	VALUE
Child's mean age (SD), years	13.5 (4.2)
Child's sex (% female)	72.5
Parent's sex (% female)	93.1
Relationship to the child (%)	
Biological parent	98.0
Adoptive parent	2.0
Child's ethnicity (%)	
White (Caucasian)	78.2
Two or more ethnicities	9.9
Latin American	5.0
Arab/West Asian	3.0
Other	3.0
Do not want to answer	1.0
Household income, %	
<$10,000 to $29,999	6.1
$30,000 to $59,999	11.2
$60,000 to $89,999	11.2
More than $90,000	52.0
Do not want to answer	19.4
Mean school days missed in the past 3 months (SD)	7.6 (9.6)

Table 2. Descriptive Statistics for Child and Parent Variables (N = 102)

Variable	Child Report, Mean (SD)	Parent Report, Mean (SD)
Parent PTSD symptoms (PCL-5), total		11.0 (13.7)
Child PTSD symptoms (CPSS-5), total	16.2 (16.7)	
Parent catastrophizing about child pain (PCS-P), total		21.1 (8.7)
Child pain catastrophizing (PCS-C), total	25.1 (10.3)	
Child pain intensity (PROMIS), total	5.5 (2.1)	
Child pain interference (PROMIS), T-score	57.2 (9.1)	

Abbreviation: CPSS-5, Child Post-traumatic Stress Disorder Scale.
NOTE. Means of prorated total scores are shown for PCS-P, PCS-C, PCL-5, and CPSS-5 measures. Mean of T-score is shown for pain interference.

Procedure

Before the first clinic appointment, children and parents consented using an online consent form and completed questionnaires separately via REDCap, a secure online data collection tool.[29] Parents completed psychometrically sound self-report measures of PTSD symptoms and catastrophic thinking about child pain. Youth completed psychometrically sound self-report measures of PTSD symptoms, pain catastrophizing, pain interference, and pain intensity. A standard approach of contacting families up to 4 times at regular intervals, reminding them to complete study measures, was implemented. After this, no further contact was made. The institutional research ethics board approved study procedures.

Measures

Demographic Characteristics

Parents reported on their own and their child's sex, ethnicity, child's age, and household annual income.

PTSD Symptoms: Youth

PTSD symptoms in youth were assessed using the self-report Child PTSD Symptom Scale, which assesses PTSD symptoms according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5).[24] As per instructions, youth were asked to recall and identify a scary or upsetting incident (eg, a car accident, living through a natural disaster, or being a victim of a crime). Youth then rated 20 symptoms (eg, "Having bad dreams or nightmares") on a 5-point Likert scale in terms of the frequency with which they had occurred in relation to that event in the past month (anchors: 0 = "not at all," 4 = "6 or more times a week/almost always"). The 20 items correspond to the DSM-5 PTSD-associated symptom clusters of re-experiencing, avoidance, alterations in cognition and mood, and hyperarousal. Items are summed to yield a total symptom severity score. Higher scores represent higher levels of PTSD symptoms and impairment, and scores of 31 or higher are indicative of clinically significant PTSD symptoms.[11] The previous version of the scale showed excellent reliability and validity.[38] This measure has been used in previous research examining PTSD symptoms in pediatric chronic pain.[42]

PTSD Symptoms: Parent

PTSD symptoms of parents were assessed using the PTSD Checklist for DSM-5 (PCL-5).[61] Parents were asked to think about the worst event that has ever happened to them and then rate how much 20 symptoms bothered them over the past month (anchors 0 = "not at all," 4 = "extremely"). The 20 symptoms correspond to DSM-5 PTSD symptom clusters of hypervigilance, negative cognitions and mood, avoidance, and re-experiencing.[2] The total score of PTSD symptom severity is computed by summing the obtained responses. A score of 33 is the current clinical cutoff.[56] The PCL-5 has shown excellent test-retest reliability, internal consistency, and discriminant validity,[6] and has been used to assess PTSD symptoms in parents of youth with chronic pain.[42]

Pain Catastrophizing Scale: Child and Parent Versions

Catastrophic thoughts about child pain were assessed using the Pain Catastrophizing Scale-Child version (PCS-C)[15] and the Pain Catastrophizing Scale-Parent version (PCS-P).[26] Each scale contains 13 items that are rated on a 5-point Likert scale (anchors 0 = "not at all," 4 = "extremely"). The PCS-C describes what a child might feel and think when they experience pain (eg, "When I am in pain, I become afraid that the pain will get worse"). The PCS-P assesses how a parent might feel when his/her child is in pain (eg, "When my child is in pain, I become afraid that the pain will get worse"). The items are summed to produce a total score. Lower scores indicate a lower level of pain catastrophizing. The PCS-C and the PCS-P have been reported to have good validity and reliability and have been previously validated in pediatric populations with chronic pain and their parents.[15,26]

Pain Characteristics: Youth

Youth completed the valid and reliable Pain Questionnaire.[47] Participants reported their pain location using a body map.[53,57] Pain frequency was rated on a 5-point Likert scale ranging from "rarely present pain (occurs every few days or weeks)" to "always present (always the same intensity)." Youth also reported how long their pain problem had been present in years and months.

Pain Outcomes: Pain Interference and Intensity

The Patient-Reported Outcomes Measurement Information System (PROMIS) pediatric profile was administered to youth. The pain interference subscale and pain intensity item were used to assess pain interference and pain intensity. The PROMIS instruments were rigorously developed as a part of the National Institutes of Health toolbox to assess a variety of physical and mental health conditions across the lifespan. The 4 items of the Pain Interference subscale are rated using a 5-point Likert scale (anchors 0 = "never," 4 = "almost always").[31] The responses are summed to obtain the total score of pain interference and subsequently transformed into standardized T-scores used for analyses. This measure has been validated for use in youth with chronic pain.[33] The pain intensity item of the PROMIS pediatric profile is rated on an 11-point numeric rating scale (0 = "no pain," 10 = "worst pain you can think of") to assess average pain intensity experienced in the past 7 days.

Statistical Analyses

Statistical analyses were conducted using SPSS version 23 (IBM Corp, Armonk, NY). On the basis of previously published data[42] and power of .8, the current sample size exceeds that required on the basis of a priori statistical power calculations (G*Power).[22] A power analysis for proposed linear multiple regression analyses with a medium effect size (f^2 = .15, α = .05, predictors = 4) suggested a total sample size of 85 dyads would provide 80% power to detect group differences and interactions in the proposed study design. Accordingly, our current sample of 102 dyads exceeds the proposed sample size required. In line with recommendations for increasing statistical power for mediation analyses, we used bias-corrected bootstrapping, a resampling technique that has been shown to increase statistical power.[25,55] Similar to previous research, only participants who completed at least 80% of items in each questionnaire were included in analyses.[46] Data were examined and determined to be missing completely at random[35] and all scale scores with less than 20% missing data were prorated (5% of the PCL-5 items; 3% of the Child PTSD Symptom Scale items; 4% of the PCS-P items; 2% of the PCS-C items).[21] Descriptive, correlational, and mediation analyses were conducted using 2-tailed hypothesis testing. Descriptive statistics were conducted to characterize the sample and calculate mean scores on key variables. T-tests were conducted to determine whether there were differences in key variables as a function of child age and sex. Bivariate Pearson correlations were conducted between the variables of interest to justify the inclusion or exclusion of these variables in subsequent mediation analyses.[41] Mediation models were tested using the Preacher and Hayes' PROCESS macro for SPSS (IBM Corp).[51]

To test for mediation, the effects of interest and their corresponding weights were examined (Fig 1). In testing for mediation, it is the indirect effect that is of primary importance, rather than the direct effects.[63] Mediation effects in the absence of significant direct effects are referred to as indirect-only mediation.[63] In line with previous research on pediatric chronic pain,[34] child age and sex were controlled for in all mediation analyses. The significance of the indirect effect was tested using bootstrapping with 5,000 samples to maximize the robustness of the results. The bootstrapping method of testing the significance of indirect effects in mediation models has several advantages over other methods (eg, the Sobel test).[51] Confidence intervals that do not contain 0 are indicative of an indirect effect, suggesting with 95% confidence that the indirect effect is not 0.[23] Thus, mediation was considered established if the confidence interval did not contain 0.

Results

Descriptive Statistics

Youth pain catastrophizing scores averaged 25.1 (SD = 10.3). According to empirically-derived clinical reference points among youth with chronic pain,[49] nearly half (49%) of youth reported "high" levels of pain catastrophizing, 35% reported "moderate" levels of pain catastrophizing, and 16% reported "low" levels of pain catastrophizing. Parent catastrophizing scores averaged 21.1 (SD = 8.7). Parent PTSD scores averaged 11.0 (SD = 13.7) with 9% of parents reporting PTSD symptoms at or above the clinical cutoff of 33, indicating clinically significant elevations in PTSD symptoms. Child PTSD scores averaged 16.2 (SD = 16.7) with 20% of youth reporting PTSD symptoms at or above the clinical cutoff of 31 (S. Capaldi, personal communication),[11] indicating clinically significant elevations in PTSD symptoms. The types of traumatic events endorsed by children in this sample were coded by 2 independent coders according to categories used by Noel and colleagues[42] (Table 3). Age was not significantly correlated with child PTSD or pain catastrophizing levels (P > .05). There were no significant sex differences in PTSD symptoms or levels of pain catastrophizing report (P > .05). Age and sex were not significantly correlated with pain intensity or pain interference (P > .05). The number of school days the child missed in the past 3 months was significantly correlated with parent catastrophic thinking about child pain (r = .27, P = .013). To examine the correlation between ethnicity and key variables, ethnicity was coded into 2 groups: white and not white. These groups did not significantly differ on any key variables. Youth from families who reported annual income between $30,000 and $59,999 had significantly higher levels of PTSD symptoms as compared with families who reported annual income between $60,000 and $89,999 (P = .019) and greater than $90,000 (P = .009). Other key variables did not differ as a function of income. Children who reported 2 or more pain locations had higher levels of PTSD symptoms (P = .008), pain catastrophizing (P = .003), and pain interference (P < .001). They also had parents with higher levels of PTSD (P = .008) and pain catastrophizing (P = .036). Pain intensity did not differ as a function of number of pain locations. There were no statistically significant differences with regard to demographic variables between
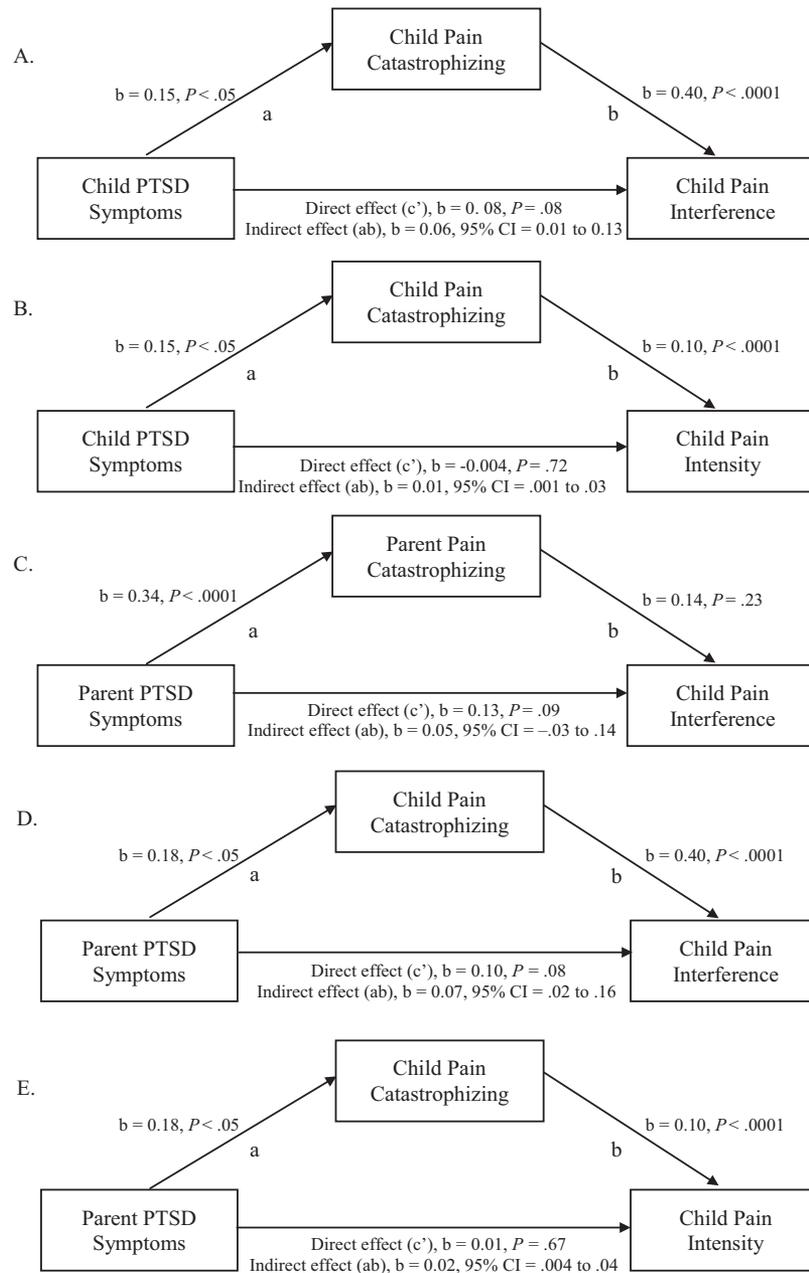
Figure 1. (A) The association between child PTSD symptoms and child pain interference is mediated by child pain catastrophizing. (B) The association between child PTSD symptoms and child pain intensity is mediated by child pain catastrophizing. (C) The association between parent PTSD symptoms and child pain interference is not mediated by parent catastrophizing about children's pain. (D) The association between parent PTSD and child pain interference is mediated by child pain catastrophizing. (E) The association between parent PTSD and child pain intensity is mediated by child pain catastrophizing. The total effect of PTSD symptoms on child pain (weight *c*) consisted of a direct effect of PTSD symptoms on child pain outcomes (weight *c'*), and an indirect effect of PTSD symptoms on child pain through the mediator, pain catastrophizing (weight *ab*). Weight *a* represents the effect of PTSD symptoms on pain catastrophizing and weight *b* represents the effect of pain catastrophizing on child pain outcomes (ie, pain interference or pain intensity), partialing out the effect of PTSD symptoms.

participants who were included in analyses and those who were excluded because of incomplete data.

Correlational Analyses

Results of correlational analyses are shown in Table 4. Higher levels of parent PTSD symptoms were associated with increased child pain interference (r = .22, *P* < .05) but not pain intensity (r = .14, *P* = .16). Higher levels of child PTSD symptoms were associated with increased child pain interference (r = .26, *P* < .01), but not intensity (r = .08, *P* = .41). Child PTSD symptoms were not related to parent catastrophizing about child pain (r = .06, *P* = .57). Therefore, parent catastrophizing was not included as a mediator in models examining the relationship between child PTSD symptoms and child pain outcomes. Similarly, parent pain catastrophizing was not related to child pain intensity (r = .07, *P* = .46); thus, pain intensity was

Table 3. Types of Traumatic Events Endorsed by Youth

Type of Event	Youth Endorsement of Each Type of Event, %
Physical illness or hospitalization	11.76
Fear/anxiety	9.80
Other	8.82
Chronic pain problem	6.86
Accident	6.86
Physical abuse	5.88
Death	4.90
Social difficulties	4.90
Sexual abuse	3.92
Verbal conflict or abuse	2.94
Family related conflict	1.96
Academic difficulties	1.96
Divorce	.98
Natural disaster	.98
Fire	.98
Pet or animal	.98
Substance abuse	.98
Gunpoint	.98
Relocation	.98

NOTE. Twenty-five percent of children reported traumatic events that met criterion A of DSM-5 diagnostic criteria for post-traumatic stress disorder.

excluded from mediation models examining parent catastrophizing as a mediator. On the basis of these results, a total of 5 mediation models were tested as described in the following sections. Fig 1 shows the results of each tested mediation model.

Mediation Analyses

The Mediating Role of Child Pain Catastrophizing in the Relationship Between Child PTSD and Child Pain

Two separate analyses were conducted to test the mediating role of child pain catastrophizing in the association between child PTSD symptoms and child pain interference and pain intensity. Results revealed an indirect effect of child PTSD symptoms on child pain interference through child pain catastrophizing ($b = .06$, 95% confidence interval [CI] = .01–.13), thus establishing mediation. Likewise, there was an indirect effect of child PTSD symptoms on child's pain intensity through child pain catastrophizing

($b = .01$, 95% CI = .001–.03), thus establishing mediation. Because there was no direct effect of child PTSD on pain intensity, this was indirect-only mediation.[63] Regression coefficients and indirect effects are shown in Table 5.

The Mediating Role of Parent Pain Catastrophizing in the Relationship Between Parent PTSD Symptoms and Child Pain

One mediation analysis was conducted to test the mediating role of parent pain catastrophizing in the association between parent PTSD symptoms and child pain interference. Results revealed that there was not an indirect effect of parent PTSD on child's pain interference through parent catastrophizing about child pain ($b = .05$, 95% CI = −.03 to .14); thus, mediation was not established. Regression coefficients and indirect effects are shown in Table 5.

The Mediating Role of Child Pain Catastrophizing in the Relationship Between Parent PTSD Symptoms and Child Pain

Two separate analyses were conducted to test the mediating role of child pain catastrophizing in the associations between parent PTSD-child pain interference and parent PTSD-pain intensity. The results revealed an indirect effect of parent PTSD on child's pain interference through child pain catastrophizing ($b = .07$, 95% CI = .02–.16), thus establishing mediation. Likewise, there was an indirect effect of parent PTSD symptoms on child's pain intensity through child pain catastrophizing ($b = .02$, 95% CI = .004–.04), thus establishing mediation. There were no direct effects of parent PTSD on pain interference or pain intensity; thus, this provides evidence for indirect-only mediation.[63] Regression coefficients and indirect effects are shown in Table 5.

Discussion

To our knowledge this is the first study to examine parent and child catastrophic thinking about pain as mechanisms underlying relationships between parent and child PTSD and child pain outcomes in youth with chronic pain. In the present sample, 20% of youth and 9% of parents reported clinically elevated levels of PTSD symptoms. Similar to previous research,[42] parent and child PTSD symptoms were related to child pain outcomes (ie, pain

Table 4. Correlations Among Variables of Interest*

Variable	1	2	3	4	5	6
1. Parent PTSD symptoms	−	.31**	.54**	.22***	.14	.22***
2. Child PTSD symptoms		−	.06	.23***	.08	.26**
3. Parent catastrophizing about child pain			−	.36**	.07	.20***
4. Child catastrophizing about pain				−	.49**	.52**
5. Child pain intensity					−	.48**
6. Child pain interference						−

*P < .001.
**P < .01.
***P < .05.

Table 5. Regression Results for Each Mediation Model

MODEL	B	SE	T	P	CI_{BCA}
1					
Child PTSD → child catastrophizing (a)	.15	.06	2.45	<.05	.03 to .27
Child catastrophizing → pain interference (b)	.40	.08	5.19	<.0001	.24 to .55
Child PTSD → pain interference (c′)	.08	.05	1.74	.0845	−.01 to .17
Child PTSD → child catastrophizing → pain interference (a × b)	.06	.03			.01 to .13
ab_{CS}	.11	.06			.01 to .24
2					
Child PTSD → child catastrophizing (a)	.15	.06	2.45	<.05	.03 to .27
Child catastrophizing → pain intensity (b)	.10	.02	5.31	<.0001	.06 to .14
Child PTSD → pain intensity (c′)	−.004	.01	−.36	.7214	−.03 to .02
Child PTSD → child catastrophizing → pain intensity (a × b)	.01	.01			.001 to .03
ab_{CS}	.12	.06			.01 to .26
3					
Parent PTSD → parent catastrophizing (a)	.34	.05	6.23	<.0001	.23 to .45
Parent catastrophizing → pain interference (b)	.14	.12	1.22	.2268	−.09 to .37
Parent PTSD → pain interference (c′)	.13	.07	1.70	.0927	−.02 to .27
Parent PTSD → parent catastrophizing → pain interference (a × b)	.05	.04			−.03 to .14
ab_{CS}	.06	.06			−.06 to .20
4					
Parent PTSD → child catastrophizing (a)	.18	.07	2.51	<.05	.04 to .33
Child catastrophizing → pain interference (b)	.40	.08	5.17	<.0001	.24 to .55
Parent PTSD → pain interference (c′)	.10	.06	1.74	.0846	−.01 to .21
Parent PTSD → child catastrophizing → pain interference (a × b)	.07	.03			.02 to .16
ab_{CS}	.11	.05			.03 to .23
5					
Parent PTSD → child catastrophizing (a)	.18	.07	2.51	<.05	.04 to .33
Child catastrophizing → pain intensity (b)	.10	.02	5.11	<.0001	.06 to .13
Parent PTSD → pain intensity (c′)	.01	.01	.43	.6655	−.02 to .03
Parent PTSD → child catastrophizing → pain intensity (a × b)	.02	.01			.004 to .04
ab_{CS}	.12	.05			.03 to .24

Abbreviations: ab_{cs}, completely standardized indirect effect of X on Y; CI_{bca}, 95% confidence interval; SE, standard error.

NOTE. N for analyses is 102 cases for each model. Analyses are controlled for child age and sex. The total effect of PTSD symptoms on child pain (weight c) consisted of a direct effect of PTSD symptoms on child pain outcomes (weight c′), and an indirect effect of PTSD symptoms on child pain through the mediator, pain catastrophizing (weight ab). Weight a represents the effect of PTSD symptoms on pain catastrophizing and weight b represents the effect of pain catastrophizing on child pain outcomes (ie, pain interference or pain intensity), partialing out the effect of PTSD symptoms.

interference). However, PTSD symptoms were not related to child pain intensity in this study. It is possible that PTSD symptoms are more related to other affective pain qualities (eg, pain unpleasantness, pain-related fear) and functioning rather than to the magnitude of pain intensity. Items measuring pain interference (eg, having trouble sleeping or paying attention when in pain) share similarities with PTSD symptoms. Moreover, pain intensity was assessed using a single item asking children about their pain intensity over the past week, and may not capture the complexity, and in particular, the affective aspects, of the pain experience for children enduring chronic pain in the longer-term. The finding that parent and child PTSD symptoms were related to child pain interference is clinically relevant, because pain interference is arguably the most critical target in interventions for these youth.[19] Consistent with hypotheses, child catastrophic thinking about pain mediated relationships between child and parent PTSD symptoms and child pain outcomes. These findings highlight one possible cognitive-affective process through which parent and child PTSD symptoms influence pain trajectories in youth. Conversely, these relationships were not mediated by parent catastrophic thinking about child pain, which under-

scores the importance of the intrapersonal context of catastrophizing in this co-occurrence.

Higher levels of parent pain catastrophizing was associated with higher levels of parent, but not child, PTSD symptoms, child catastrophizing, and child pain interference. However, parent catastrophizing, contrary to hypotheses, did not mediate the relationship between parent PTSD symptoms and child pain interference. Because of the crucial role that parents play in pediatric chronic pain,[48] these null findings may be explained by the presence of more complex mechanisms underlying parent catastrophizing and pediatric chronic pain. For instance, higher levels of parent pain catastrophizing might lead parents to engage in protective behaviors that, in turn, lead to higher pain interference in children. Parent catastrophic thinking about their child's pain might influence child pain catastrophizing, as evidenced by the correlation between the 2 variables, which mediates the PTSD-pain relationship. Thus, parent pain catastrophizing may play a role in this relationship, albeit in more indirect ways.

Findings from this study emphasize the importance of examining the influence of parent as well as child PTSD symptoms on children's pain outcomes and provide empirical support for the recently proposed mutual maintenance model of

co-occurring PTSD symptoms and pediatric chronic pain.[30] Consistent with the model, the intrapersonal context of catastrophizing was found to underlie co-occurring symptoms of child and parent PTSD symptoms and child pain. In addition to the influence of catastrophic thinking about pain, the relationship between chronic pain and PTSD symptoms may be influenced by attentional vigilance toward threat and pain, parent and child threat appraisals of pain, parent-child communication (eg, language that draws attention to pain), and parent responses to child pain (eg, protectiveness).[30] The finding that child PTSD symptoms influence child pain outcomes through child, but not parent, pain catastrophizing may be in part because of the internalizing nature of PTSD symptoms.

The current study highlights child pain catastrophizing as a cognitive-affective mechanism through which PTSD symptoms may contribute to worse chronic pain outcomes in youth. PTSD and pain catastrophizing are both multidimensional constructs that may share similar negative cognitions. Symptom characteristics of PTSD, such as hypervigilance, re-experiencing, and alterations in mood and cognitions, may overlap with or increase vulnerability to catastrophic thoughts about pain (ie, magnification of pain cues, rumination, and helplessness). For example, elevated PTSD symptoms, which often overlap with PTSD as well as chronic pain,[3] have been associated with attentional biases toward threat,[10] and in turn, may increase the likelihood of engaging in catastrophic thinking. However, there is evidence to suggest that catastrophic thinking as an emotion regulation strategy before traumatic events may be associated with increased risk of developing PTSD symptoms.[32] The cognitive model of PTSD of Ehlers and Clark posits that individuals who have a trait-like tendency toward maladaptive appraisals are more likely to perceive a sense of threat after a traumatic event.[20] Indeed, in the adult literature, catastrophic thinking, specifically maladaptive self-appraisals, have been shown to predict the development of PTSD in firefighters.[9]

This study did not examine parent behavioral responses (eg, protective responses) that may explain how child pain catastrophizing mediates the association between parent PTSD symptoms and child pain. However, parent solicitous and protective behaviors, known to exacerbate children's pain,[39] have been linked to increased child catastrophic thinking about pain.[17,28] Cognitive demands from PTSD symptoms may interfere with parents' ability to manage their own physical and mental health, which may make them more likely to engage in pain promoting/protective behaviors (eg, keeping the child from engaging in activities that could cause pain). This could inadvertently increase child pain catastrophizing and influence worse child pain outcomes. PTSD symptom elevations may also impede parents' ability to engage in behavior change required of psychological interventions for pediatric chronic pain (limiting attention to pain, encouraging activities despite the pain), which could affect children's cognitions and feelings about their pain and ultimately, their pain outcomes. Future research should investigate the role of parental responses to pain in the pathway from parent PTSD to children's pain outcomes (ie, the interpersonal context).

The current findings provide further support for the importance of addressing the mental health needs of parents of children with chronic pain. Parenting a child with chronic pain is a complex experience associated with anxiety and depressive symptoms as well as role stress.[18] However, elevations in PTSD symptoms of parents of youth with chronic pain have only been shown once before.[42] In the present sample, 9% of parents had clinically elevated (ie, above the clinical cutoff) PTSD scores; however, relatively higher levels of (vs diagnostic levels of) parent PTSD symptom scores in this study were linked to worse child pain interference, a relationship that was mediated by child pain catastrophizing. These findings highlight the importance of addressing parent PTSD symptoms in interventions for pediatric chronic pain. Parent components of existing cognitive behavioral therapy interventions for pediatric chronic pain focus on changing parent behavioral strategies (eg, to reinforce adaptive behaviors),[19] without explicitly addressing parent distress or mental health symptoms that are often present. Parent-only behavioral or cognitive interventions for pediatric chronic pain are not standard; however, novel treatment advances have been made. For example, Palermo and colleagues[46] recently examined a problem-solving skills training intervention to reduce distress among parents of youth with chronic pain. Findings from this trial showed that the intervention was associated with improvements in parent depression, general mental health, and pain catastrophizing.[46] It is unknown if this therapeutic approach would serve to reduce parent PTSD symptoms.

Current treatments for pediatric chronic pain do not explicitly address co-occurring mental health issues such as elevated anxiety, PTSD, and depressive symptoms. In children with chronic pain, those with comorbid clinically elevated levels of anxiety have been shown to be less likely to respond to pain intervention, as indicated by less reduction in pain intensity and functional disability.[16] Two case studies have investigated the application of a transdiagnostic multimodal treatment for youth with chronic pain comorbid with anxiety or depression and showed the potential utility of addressing the comorbidity simultaneously.[1] Identifying youth with co-occurring mental health disorders and symptom elevations and tailoring interventions to meet their needs, may improve the effect of interventions and children's pain trajectories.

The current findings should be considered in light of limitations, which can be used to propel forward research in this area. First, the current study relied on psychometrically sound self-report measures of PTSD at the symptom level, because of the importance of symptoms in conceptual models of co-occurrence[30] as well as empirical research showing a relative link to poorer pain and functional outcomes.[42] Clinical cutoffs were applied and self-identified events were coded for content and whether or not they met criterion A of DSM-5 criteria for PTSD[2] (Table 5); however, the utility of criterion A has been debated in the literature because of its poor predictive validity,[5,58] which further supports examination at the symptom level. Nevertheless, future research should

also assess clinical diagnoses of PTSD using clinician-administered interviews to examine these relationships in youth who do and do not meet diagnostic criteria for PTSD. Future research might also consider examining whether these relationships differ on the basis of the types of traumatic events (eg, sexual/physical abuse vs physical illness) experienced by youth. Second, because of the cross-sectional nature of this study, the directionality of the relationship between PTSD symptoms, catastrophic thinking, and pain outcomes could not be teased apart. PTSD symptoms and pain should be assessed longitudinally to determine the influence of pain catastrophizing as a mechanism in their mutual maintenance. Research in other pediatric populations, such as traumatic brain injury, suggests that PTSD symptoms may be a stronger driver of pain symptoms than vice versa,[8] however, prospective research investigating the temporal relationship between chronic pain and PTSD in chronic pain populations has yet to be conducted. Future research should also strive to longitudinally assess proposed mechanisms, such as pain catastrophizing, to shed light on the sequence of symptom onset and how this co-occurrence becomes established and maintained over time. In addition, most models of co-occurrence are specific to the co-occurrence of PTSD and pain,[30,54] however, others[4] have proposed mechanisms that are thought to underlie the co-occurrence of chronic pain, PTSD, and anxiety disorders. In Asmundson and Katz's theoretical model,[4] pain catastrophizing is implicated as a factor underlying the co-occurrence of anxiety (including PTSD) and chronic pain, thus, we expect that catastrophizing may underlie both co-occurrences (ie, PTSD and chronic pain/anxiety and chronic pain). Nevertheless, because of core differences in PTSD and anxiety, more research is needed to determine the unique contributions of posited mechanisms.

Catastrophizing is thought to be modifiable and would be expected to alter pain outcomes.[14] Indeed, Weiss and colleagues reported a significant reduction in pain catastrophizing in a sample of youth with chronic pain after an outpatient interdisciplinary rehabilitation program.[62] Nevertheless, directly modifying patterns and aspects of catastrophic thinking about pain remains an important area for future research. Investigation into parent behavior is another important area of future research to understand how parent PTSD symptoms could be communicated to the child to influence child catastrophic thinking and child pain. Parent behaviors may also be implicated in relationships between child PTSD, child catastrophizing, and child pain. Because parent be-

haviors are likely dynamic over time,[12] longitudinal studies of parent behaviors in these relationships should be conducted to tease the sequence of these relationships apart over time.

Third, most participating parents in this study were mothers. Future studies should include fathers to investigate their influence in the PTSD-child pain relationship and to expand the scope of this research to the whole family. In addition, although proration is a commonly used method for handling item-level missing data, there are limitations to prorating data, including variation in the meaning of the scale across participants and the potential for bias in measures of variation and association.[21] In the current sample, a small percentage of data were prorated (between 2 and 5% of scores for each scale) and, before prorating, all missing data were first determined to be missing completely at random. Finally, catastrophic thinking is one of many proposed mechanisms that could be driving the PTSD-pain relationship. Elucidating the roles of other intrapersonal (eg, sleep disturbance, perceived injustice), interpersonal (eg, parent protective responses), and neurobiological (fear-based neural circuitry, candidate genes) factors will be critical for enhancing our understanding of this co-occurrence and informing tailored interventions for these vulnerable youth.[60]

Conclusions

To our knowledge, this research is the first to show the mediating role of child pain catastrophizing in the relationships between parent and child PTSD symptoms and child chronic pain outcomes. Findings revealed that child, but not parent, catastrophic thinking about pain mediated the relationships between child and parent PTSD symptoms and child pain outcomes. These findings provide empirical support for the recently proposed mutual maintenance model of co-occurring PTSD symptoms and pediatric chronic pain and underscore the importance of assessing parent as well as child PTSD symptoms and child cognitive appraisals about pain in this context. Catastrophic thinking about pain and PTSD symptoms could be modified in psychological interventions, thereby illuminating new avenues for tailored interventions for these youth. Greater understanding of the specific mechanisms underlying the co-occurrence of PTSD symptoms and pediatric chronic pain will inform how to improve trajectories of chronic pain and mental health symptoms in these youth.

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