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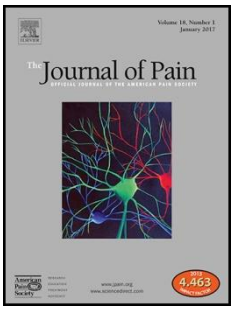

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Sleep Mediates the Association between PTSD Symptoms and Chronic Pain in Youth

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Keywords: chronic pain, PTSD/Posttraumatic Stress Disorder, Trauma, child/adolescent, sleep

Highlights

- Sleep quality partially mediated the association between post-traumatic stress symptoms (PTSS) and pain characteristics among a cohort of youth with chronic pain.
- Higher PTSS was associated with higher levels of both pain intensity and pain interference and these PTSS-pain relationships were partially explained by poor sleep quality.
- Findings provide empirical support for the pediatric model of mutual maintenance in PTSS and chronic pain, which posits that sleep disturbance is a key intrapersonal factor driving this co-occurrence.
- Sleep is a modifiable mechanism that could be targeted in interventions, which might alter a trajectory of pain and comorbid mental health problems from persisting into adulthood.

Abstract

Symptoms of post-traumatic stress disorder (PTSS) and chronic pain have been shown to co-occur at high rates in adolescents and this co-occurrence is linked to worse pain and quality of life. Sleep disturbance has been posited as a mechanism underlying this co-occurrence in conceptual models of mutual maintenance. This study examined the mediating role of sleep in the relationship between PTSS and pain in youth (aged 10-17 years) with chronic pain. Ninety-seven participants completed measures of PTSS, pain (intensity and interference), anxiety symptoms, and sleep quality, in addition to demographics. Mediation models were conducted. Findings revealed that, over and above the influence of associated demographics (age, race) and anxiety symptoms, sleep quality partially mediated the relationships between PTSS and pain

intensity and interference for youth with chronic pain. Specifically, higher PTSS was linked to higher levels of pain intensity and pain interference, and these relationships were partially explained by poor sleep quality. Findings highlight the potential mechanistic role of sleep in explaining the co-occurrence of chronic pain and PTSS and suggest sleep might be an important target in future interventions.

Trauma, either in the form of neglect, threat of death or injury, and/or physical or sexual violence is prevalent among youth. Approximately 25% of youth experience at least 1 traumatic event by age 16,[12] and more than 60% have experienced a traumatic event in adolescence.[44, 64] Developmental differences in rates of occurrence have been found: adolescents are exposed to a greater number of traumatic events than adults, and this is associated with higher rates of PTSD, particularly among females (7% females vs. 2% males).[44, 51] PTSD during childhood and adolescence can have long-term consequences. Longitudinal studies have linked early life trauma and PTSD to poorer health in adulthood,[10, 47, 52] including sleep problems,[70] chronic pain,[56, 59] and anxiety disorders.[6, 30]

The relationship between PTSD and pain is intriguing given their high comorbidity and shared conceptualization about factors leading to their development and maintenance.[3, 28, 66] Chronic pain in adolescence is prevalent,[34] costly,[22] and increases risk for chronic pain and internalizing mental health conditions in adulthood.[19, 67] In adults, the co-occurrence of PTSD and chronic pain has been explained by the presence of shared neurobiology and mutually maintaining factors that lead to the development and/or maintenance of both conditions.[3, 4, 28, 66]

Importantly, in both adult and pediatric chronic pain populations, even subclinical symptoms of PTSD (PTSS) are clinically important.[50] In a recent study, while the types of distressing and traumatic events largely did not differ between youth with versus without chronic pain, youth with chronic pain were found to have higher rates of clinically elevated PTSS (32%), as compared to those without chronic pain (8%). Among youth with chronic pain, individuals who had higher PTSS had worse pain outcomes and quality of life.[50] Unmanaged pain in adolescence may lead to internalizing mental health conditions in adulthood, even if their pain resolves.[19, 29] A recent epidemiological study with a community sample revealed that the presence of adolescent chronic pain was associated with higher rates of PTSD into adulthood.[49]

One potentially modifiable mechanism that may underlie the co-occurrence of chronic pain and PTSS is sleep disturbance. Hyperarousal, which includes sleep disturbance and hypervigilance, is associated with PTSS, and is 1 of the 4 symptom clusters used to diagnose PTSD.[2] Hyperarousal is a consequence of having heightened anxiety and arousal responses, which may result in difficulty falling or staying asleep and impairment in overall sleep quality. Importantly, evidence suggests that sleep is not simply a secondary symptom of PTSD, but rather is a risk factor for worsening symptoms of the disorder.[36, 82] The impact of sleep difficulties on youth with chronic pain is also well described.[5, 8, 45, 46, 61, 72] Sleep problems in youth with chronic pain are persistent and are associated with poorer quality of life, greater activity limitations, and more frequent healthcare utilization.[53-55] Initially, a bi-directional relationship between pain and sleep was theorized.[39] However, experimental and population-based longitudinal studies, albeit primarily in adults, suggest that sleep impairment reliably predicts new incidents and exacerbations of chronic pain.[20] Temporal daily associations among sleep and pain in children and adults with chronic pain have been documented, with relatively stronger impact of sleep on

next day pain than vice versa.[1, 38, 60]

Sleep disturbances were highlighted in a recent model proposing key factors that may serve to mutually maintain chronic pain and PTSS in youth.[28] Mutual maintenance and shared vulnerability models posit that while chronic pain and PTSD may indeed be separate and unrelated conditions, underlying vulnerability and symptoms shared by both conditions may serve to mutually maintain both chronic pain and PTSS (for a review of the models see Vinall et al.[73]). Specifically, PTSS (e.g. hyperarousal) may contribute to poorer sleep quality, thereby increasing pain sensitivity, pain-related anxiety, and pain-avoidant behaviors, which can result in chronic pain. Moreover, ongoing sleep disturbances may serve to maintain PTSS and chronic pain over time. However, research has not empirically examined whether sleep quality underlies the association between PTSS and pain (i.e. intensity and interference). The current study fills this gap by examining sleep quality as a mediator in the association between PTSS and pain intensity and interference in youth with chronic pain. Based on recent conceptual models of mutual maintenance,[28] we hypothesized that poorer sleep quality would mediate the associations between higher PTSS and greater pain intensity and interference in youth with chronic pain.

Method

This study was conducted at academic medical centers in the northwestern United States. All study procedures were approved by the primary Institutional Review Board. Details regarding assenting/consenting procedures, and administration of questionnaires have been previously published in an initial study reporting on prevalence of PTSS in parents and youth with and without chronic pain and its relationship to pain and quality of life.[50] The aims of the current study were distinct from this previously published work.

Participants

Study participants included youth aged 10 to 17 years who had ongoing chronic pain (n = 97) and a parent. Adequacy of the sample size for this paper was confirmed using a post-hoc power analysis in a statistical power analysis program (G*power).

Children and adolescents with chronic pain were recruited from specialty pediatric chronic pain clinics at 2 tertiary level children's hospitals in the Northwestern United States. All youth were diagnosed as having a chronic pain condition by a physician. Inclusion criteria for youth with chronic pain were: pain present for 3 months or more and presence of ongoing pain (i.e., pain intensity > 0/10 in the past month) at the time of screening. Children with life-threatening conditions (e.g., cancer) were excluded in order to reduce heterogeneity in the sample given that PTSS in the context of having a life threatening illness may be qualitatively different.[41, 69] This exclusion criteria has similarly been used in previous research [50, 11, 80]

To be included in the study, participants were required to be fluent in English, free of cognitive impairments or developmental disabilities, able to independently complete study questionnaires, and have access to the Internet. Study questionnaires were administered using Research Electronic Data Capture (REDCap),[25] a secure online data collection portal. Each child was provided with an individual login with instructions to complete the measures independent from their parents. This login securely linked to their study ID number.

Recruitment and data collection took place from March-September 2015. Of the individuals approached, 65% participated in this research study. The majority (46%) of participants who were not included either could not be reached within 4 attempts by a researcher following screening or were deemed to be not eligible to participate. The remaining participants were either not eligible (29%) or declined to participate (25%). The participant and non-participant groups did not differ on demographics assessed during screening (age, sex; ps > .05).

Eighty-eight percent of participants included in this study had complete data on all study measures.

Measures

Demographics

Each participating parent reported on their child's age and sex, and answered questions regarding their own age, sex, race, marital status, education, and family income. Parents also reported whether or not their child had a diagnosis of a physical or mental health condition or disorder. They also indicated what this condition/disorder was.

Pain Intensity and Characteristics

Youth reported on their pain intensity, and pain location over the past 7 days. Pain intensity was assessed using the 11-point Numerical Rating Scale (NRS; anchors: 0='no pain', 10='worst pain possible'),[75] which is deemed the most valid and reliable self-report pain intensity scale for this age range,[62, 68] and is the most commonly used self-report measure in the adolescent pain literature.[9] Youth also used a validated body map[63] to mark the location in which they experienced the most problems with pain (see Table 1 for a list of primary pain locations).

Pain Interference and Anxiety Symptoms

The National Institutes of Health (NIH) developed the Patient-Reported Outcomes Measurement Information System (PROMIS) Pediatric Profile instruments, which are a collection of short forms containing a fixed number of items from six domains (Depressive Symptoms, Anxiety, Mobility, Pain Interference, Fatigue, and Peer Relationships). These scales were developed using item response theory, which requires calibration of individual items. This yields a smaller standard error of measurement, which results in precise measures that are sensitive to change, thereby requiring fewer items and reducing respondent burden.[33] Of

particular interest to the aims of this study were the Anxiety and Pain Interference domains based on guiding conceptual models[4] and previous research on PTSS and pediatric chronic pain.[50] There are three profile lengths, the shortest being the PROMIS-25, which includes 4 items per domain and that was used in the current study. Each item is assessed on a 5-point Likert scale ranging from 0 ("never") to 4 ("almost always") using a reporting time frame of the past 7 days. Total raw scores are transformed into standardized T-scores and used for analysis. A higher PROMIS T-score represents greater pain interference and anxiety symptoms. These pain interference and anxiety measures have been validated for use in adolescents with chronic pain.[33] Construct validity (Intercept and slope ≥ 0.98[33]) and internal consistency of both subscales were high (anxiety symptoms – 4 items, $\alpha = .91$; pain interference – 4 items, $\alpha = .82$).

Posttraumatic Stress Disorder Symptoms

PTSS was assessed using the 27-item Child PTSD Symptom Scale (CPSS-5).[21] This scale requires that youth first think of "scary or upsetting" events (e.g., car accident, being touched in a way you did not like, having a relative get hurt or killed etc.) and then answer questions based on the experience that distressed them the most. We recorded the traumatic/distressing event reported by adolescents and coded whether or not it met Criterion A according to the DSM-5, which requires that an individual be exposed to either death, threatened death, actual or threatened serious injury, or actual or threatened sexual violence. In the present study, we focused on PTSD symptomology versus clinical diagnoses because research suggests that these symptom elevations, regardless of whether or not they are tied to a life-threatening event, are linked to worse pain intensity, interference, and quality of life.[50] Moreover, the guiding conceptual model of co-occurring PTSS and chronic pain[28] was specific to symptom elevations and not restricted to clinical diagnoses of PTSD.

The CPSS-5 includes 20 items, and requires youth to rate their symptoms of PTSD for the past month using a 4-point Likert scale ranging from 0 ("not at all") to 3 ("3-5 times a week"). A total score and scores for the 4 symptom clusters (re-experiencing, avoidance, negative cognitions and mood, hyperarousal) that map onto the DSM-5 diagnostic criteria are produced. The total symptom severity score ranges from 0 to 51, and the clinical cut-off is a score of 31. The CPSS-5 is based on the CPSS-4, which is valid and reliable. The CPSS-5 was previously used in a study of youth with and without chronic pain.[50] One of the CPSS-5 items ("having trouble falling or staying asleep") overlapped with items on the sleep quality measure (rASWS Falling Asleep and Reinitiating Sleep subscale). Therefore, all analyses were conducted using total CPSS-5 scores both with and without this particular item removed. Internal consistency for CPSS-5 was high (20 items, $\alpha = .95$, 19 items, $\alpha = .95$).

Sleep Quality

The Revised Adolescent Sleep-Wake Scale (rASWS) is a 10-item measure of subjective sleep quality for use with adolescents between the ages of 12-18 years,[16] that has been validated for use in adolescents with chronic pain.[16] Adolescents report on the frequency of various sleep problems within the past month on a 6-point Likert scale ranging from 1 ("always") to 6 ("never"). Higher scores indicate better sleep quality. The rASWS is comprised of 3 subscales: (a) Falling Asleep and Reinitiating Sleep-Revised, (b) Returning to Wakefulness-Revised, and (c) Going to Bed-Revised. The total sleep quality score had acceptable internal consistency (10 items, $\alpha = .63$) and was used in the analyses.

Data Analysis

Prior to analyses, assumptions of normality (i.e., skewness and kurtosis) were determined; no violations of normality were present in the data. Bivariate correlations were conducted between the demographic and key outcome variables (i.e. sleep quality, PTSS and anxiety symptoms, pain intensity and interference). T-tests using Bonferroni correction were used to assess differences in pain intensity and interference by race. Significant covariates were included in the mediation models. The hypothesized mediation models were tested using the PROCESS macro for SPSS.[57] The PROCESS macro uses an ordinary least squares (OLS) regression-based path analytic framework to estimate unmoderated mediation analyses.[57] Mediation analyses examined the indirect effects of independent variables (IV; e.g., PTSS) on a mediator variable (path a; sleep quality), the mediating variable on one of the dependent variables (DV; path b; pain intensity or pain interference) and the IV on the DV without the inclusion of mediators (path c). The relationship between the IV on the DV was considered after the mediator was included in the model (path c). The product-of-coefficients (paths a*b) were calculated using a bootstrapping procedure (n = 10,000 bootstrap resamples), which yielded a point estimate (PE) for the indirect or mediating effect. Mediators were considered significant if the confidence interval (CI) around the PE did not cross zero.

Results

Descriptive Statistics

The demographics of the sample and mean scores of key variables are shown in Table 1. Demographics that were significantly related to key variables were age and race. Age was significantly related to pain interference (r = .22, p = .035), PTSS (r = .25, p = .016), and anxiety scores (r = .21, p = .046). Racial groups differed on pain intensity ratings (F (4,82) = 3.40, p = .013). Therefore, the models with pain intensity as an outcome controlled for race and the models

with pain interference as an outcome controlled for age and anxiety. Youth had a variety of pain presentations; the most frequent pain locations involved the head (22%), leg (22%), and stomach (17%). The average level of pain intensity was 5.8/10 (*SD* = 1.7), with 97% of youth reporting that their usual pain intensity level in the past 7 days was 3/10 or higher. Overall, 73% of parents of youth with chronic pain (n = 71) reported that their child had a mental or physical condition/disorder. Of those 71 children, 30% had anxiety (10%), depression (7%), or both (13%). Youth who were reported to have a diagnosis of anxiety, depression, or both, had higher levels of PTSS (*M* = 32.05, *SD* = 21.57) as compared to youth who did not have anxiety or depression (*M* = 21.45, *SD* = 17.84): $t(93) = -2.29$, $p = .024$. Youth also reported a wide variety of distressing/traumatic experiences (see Table 2), with 34% of children reporting traumatic events that met Criterion A of DSM-5 diagnostic criteria for PTSD, and 32% of youth reaching the CPSS-5 clinical cut-off for PTSD. Overall, 14 youth (15% of the sample) met criterion A1 as well as the CPSS-5 clinical cut-off.

Bivariate Correlations

Higher PTSS and poor sleep quality were related to higher pain intensity and pain interference (see Table 3). Poorer sleep quality was related to higher PTSS, pain intensity, and pain interference.

Testing Sleep Quality as a Mediator of the Relationship between PTSS *and Pain Outcomes*

Two separate analyses were conducted in order to test sleep quality as a mediator of the effect of PTSS on pain intensity and pain interference, while controlling for demographic covariates (child age for pain interference, child race for pain intensity; Table 4 for standardized regression coefficients and indirect effects). We first tested whether sleep quality mediated associations between PTSS and pain intensity. Consistent with our hypothesis, sleep was a

significant partial mediator of the relationship between PTSS and pain intensity. Mediation results remained significant after also controlling for symptoms of anxiety (*PE* = .008, *SE* = 0.005, [CI_{BCa} = 0.001 – 0.019]).

We next tested if sleep quality mediated associations between PTSS and pain interference. Sleep quality was also a significant partial mediator of the relationship between PTSS and pain interference. Mediation results remained significant after controlling for symptoms of anxiety (*PE* = .052, *SE* = 0.025, [CI_{BCa} = 0.015 – 0.114]).

All of the above analyses were also conducted using a total PTSS severity score that excluded one overlapping sleep quality item ("having trouble falling or staying asleep"). The pattern of results did not change.

Discussion

This study was the first to examine sleep quality, a potential modifiable mechanism, underlying the association between PTSS and pain characteristics among a cohort of youth with chronic pain. As expected, findings revealed that sleep quality partially mediated the relationships between PTSS and pain intensity and PTSS and pain interference. Specifically, among youth with chronic pain, higher PTSS was associated with higher levels of both pain intensity and pain interference and these PTSS-pain relationships were partially explained by poor sleep quality. These findings provide empirical support for the recently proposed pediatric model of shared vulnerability and mutual maintenance in PTSS and chronic pain, which posits that sleep disturbance is a key intrapersonal factor driving this co-occurrence.[28]

Chronic pain in adolescence confers long-term risk for future chronic pain[76] and mental health disorders.[49, 67] Our findings are clinically relevant given that sleep is a modifiable mechanism that could be targeted in interventions, which might alter a trajectory of pain and

comorbid mental health problems from persisting into adulthood.[19, 29, 49, 65, 67, 76] Youth with chronic pain who have elevated internalizing mental health symptoms, such as anxiety, do not respond well to conventional pain treatments;[13] therefore, additional treatment targets are needed for these youth. Sleep disturbance might be a particularly fruitful intervention target. Although sleep interventions for co-morbid chronic pain and PTSS in youth have not yet been developed, advances in this area have been made among adults with these conditions that can guide future research and practice in pediatric populations. Sleep interventions (e.g., cognitive-behavioral therapy for insomnia- CBT-I) are considered an alternative to conventional treatments for adult PTSD[27] and are also recognized as an effective intervention component for chronic pain.[32] A recent meta-analysis of 11 randomized controlled trials of sleep-specific CBT found the interventions to be efficacious in reducing PTSD and depressive symptoms as well as insomnia severity (i.e., sleep onset latency, wake after sleep onset, sleep efficiency)[27]. Likewise, CBT-I has been shown to reduce insomnia severity[14, 15] and pain interference,[32] but not pain intensity,[14, 15] in adults with chronic pain conditions. Similar work in pediatric chronic pain populations, particularly those with elevated PTSS, is needed.

This study did not examine potential cognitive-affective, behavioral, or neurobiological pathways that may in part explain how and why poor sleep quality mediates the PTSS-chronic pain relationship. Examination of underlying mechanisms is particularly important, given that our previous research suggests that the majority (92%) of youth with chronic pain do not attribute their most distressing or traumatic event to their pain problem.[50] Thus, while some populations (e.g., veterans wounded in combat, post-surgical pain populations) might experience trauma resulting from an injury or a painful event, in the context of youth living with chronic pain seen in a tertiary level chronic pain clinic, the traumatic stress experienced is often about

events that are perceived to be unrelated to their chronic pain problem. Mutual maintenance and shared vulnerability models similarly posit that these two conditions may indeed be separate but underlying vulnerabilities (anxiety sensitivity, lower threshold for alarm) and symptoms shared by both conditions (avoidance, cognitive biases, depression, activation of fear-based circuitry) serve to mutually maintain both chronic pain and PTSS over time.[4, 28, 66] For example, arousal has been implicated in both poor sleep and chronic pain and may activate a stress response resulting in autonomic dysfunction. Moreover, the neurotransmitter, dopamine, has been implicated in sleep disturbances and these comorbid conditions. Poorer sleep quality is associated with decreased dopamine receptor availability [40, 74] and binding,[35] similar to what has been reported for patients with chronic pain[23, 24, 43, 81] and PTSD[37]. Therefore, altered dopaminergic signaling may be one mechanism through which sleep quality mediates the relationship between chronic pain and PTSS. Poorer sleep quality also leads to alterations in the opioidergic system. Preclinical research studies have demonstrated that poorer sleep quality dysregulates endogenous opioid systems and attenuates the efficacy of μ-opioid receptor agonists.[48, 71] Moreover, poor sleep quality reduces endogenous opioid levels and down regulates opioid receptors, similar to what has been observed among individuals with chronic pain. [58, 79] Thus, there are multiple avenues for future research focused on examining mechanisms linking poor sleep to the PTSS-pain relationship.

There were limitations in the current study that can be addressed in future research. First, this was a cross-sectional study; therefore, directionality cannot be determined and the results of the mediation analyses should be interpreted with caution. Previous research, albeit in non-chronic pain populations (mild traumatic brain injury), suggests that PTSS more strongly predicts pain than vice versa;[7] however, longitudinal research is needed to determine the

pathways through which PTSS and pain are related to one another and how proposed mechanisms, such as poor sleep quality, serve to maintain both conditions over time. Indeed, to determine whether factors mutually *maintain* both conditions, prospective studies are required. Second, the constructs assessed in this study were measured exclusively using self-report measures. Future research will be enhanced by inclusion of objective measures of sleep (e.g., actigraphy, polysomnography), diagnostic clinical interviews, and symptom level measures of anxiety and PTSD from multiple reporters. The measure of sleep quality did not have strong psychometric properties, and convergent validity could not be assessed in the current study given that additional measures of sleep were not administered. Relatedly, perceived sleep quality was assessed in the current study but is only one of many sleep parameters that may be important in understanding and addressing the PTSS-chronic pain relationship. Poor sleep quality may be driven by several factors, one of which is hyperarousal or anxiety at sleep initiation. Future research should examine insomnia, hyperarousal, and other sleep disturbances that are relevant to PTSS and chronic pain (e.g., post-traumatic nightmares, REM abnormalities) to determine their role in the maintenance of co-occurring PTSS and chronic pain. Finally, this study focused on one of several proposed mechanisms that may underlie this co-occurrence.[28] Undoubtedly, the myriad of intrapersonal, interpersonal, and neurobiological factors underlying the co-occurrence of PTSS and chronic pain are likely as complex as the conditions themselves. For example, cognitive biases and mood have been shown to be integrally tied to sleep disturbance,[77, 78] internalizing mental health issues and chronic pain,[4, 66] and are central in pediatric models of PTSS and chronic pain co-occurrence.[28] To best propel this research forward and inform clinical practice, studies that assess a variety of cognitive-behavioral and neurobiological mechanisms and that are couched within sound conceptual frameworks are required.

In conclusion, poor sleep quality was found to partially mediate the relationships between PTSS and pain intensity and interference among youth with chronic pain. Given emerging evidence documenting the high prevalence of clinically elevated PTSS among youth with chronic pain, which are linked to worse pain and quality of life in this already vulnerable group of youth,[50] this research is particularly timely. Relatively brief psychological interventions targeting sleep disturbances have been shown to lead to improvements in both PTSS and chronic pain symptoms in adult samples.[27, 32] Similar work in youth with co-occurring pain and PTSS, in addition to examinations of other mechanisms underlying this co-occurrence, are needed.

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Table 1. Sample socio-demographics and descriptive statistics.

Socio-demographics		n
Child's age (*M* years, SE)	15.0 (2.1)	97
Child's sex (% female)	72	97
Parent's sex (% female)	91	97
Relationship to the child (%)		97
Biological mother	88	
Biological father	8	
Adoptive mother	1	
Adoptive father	1	
Other	2	
Parent Education		97
High school or less	8	
Vocational school/some college	32	
College	38	
Graduate/professional school	22	
Child's race (%)		93
White	88	
Other	7	
Black or African-American	2	
Asian	2	
American Indian or Alaska Native	1	
Household income (%)		96
$10,000 - $29,999	13	
$30,000 - $49,999	16	
$50,000 - $69,999	14	
$70,000 - $100,000	24	
More than $100,000	34	
Pain location		
Head	22	
Leg	22	

Stomach	17	
Other	10	
Spine	8	
Neck	7	
Lower back	6	
Shoulder	3	
Feet	3	
Hand/Arm	2	
Chest	1	
Child Pain Intensity	5.8 (1.7)	91
Child Pain Interference (*t*-score)	61.4 (8.9)	93
Child Anxiety Symptoms (*t*-score)	51.6 (12.3)	92
Child PTSS	23.8 (19.1)	95
Child Sleep Quality	3.2 (0.85)	94

Table 2. Types of traumatic events.

Type of Event	Percentage of children who endorsed each event
Death	28
Physical Illness or Hospitalization	14
N/A (child recorded "N/A" or left blank)	10
Sexual Abuse	6
Physical Abuse	5
Fear/Anxiety	4
Chronic Pain Problem	4
Social Difficulties	4
Other	4
Family-related Conflict	3
Robbery/Forced Entry	3
Relocation	3
Issue Regarding Pet/Animal	2
Divorce	1
Suicide	1
Mental Illness	1
Incarceration /Legal Issues of Family Member	1
Fire	1
Academic Difficulties	1
Substance Abuse	1
Accident	1

Note. 34% of children reported traumatic events that met Criterion A of DSM-5 diagnostic criteria for posttraumatic stress disorder. Reliability coding for Criterion A was calculated on 20% of the sample; 100% agreement was attained.

Table 3. Bivariate correlations between key variables.

***N* = 95**	**1. PTSS**	**2. Sleep Quality**	**3. Pain Intensity**	**4. Pain Interference**
1. PTSS	1.00 *n* = 95	-.480*** *n* = 94	.262* *n* = 91	.519*** *n* = 93
2.		1.00 *n* = 94	-.339** *n* = 90	-.544*** *n* = 93
3.			1.00 *n* = 91	.377*** *n* = 89
4.				1.00 *n* = 89

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4. Standardized regression results for the tests of indirect effects.

Model	B	SE	t	p	CI_{bca} (LL)	CI_{bca} (UL)
Pain Intensity						
PTSS → Sleep Quality (a)	-.02	.004	-4.79	<.0001	-.03	-.01
Sleep Quality → Pain Intensity (b)	-.52	.23	-2.24	.028	-.98	-.06
PTSS → Pain Intensity (c')	.01	.01	1.28	.205	-.01	.03
PTSS → Sleep Quality → Pain Intensity (a ∗ b)	.01	.01			.002	.02
Pain Interference						
PTSS → Sleep Quality (a)	-.01	.01	-2.54	.013	-.02	-.003
Sleep Quality → Pain Interference (b)	-3.91	1.04	-3.77	.0003	-5.97	-1.85
PTSS → Pain Interference (c')	.14	.05	2.61	.011	.03	.24
PTSS → Sleep Quality → Pain Interference (a ∗ b)	.05	.03			.02	.11

Note. N for analyses included 90 cases for models including pain intensity and 91 cases for models including pain interference. PTSS (CPSS-5, Total Score) was the independent variable (IV) in all models. Sleep Quality (rASWS, Total score; M), Pain Intensity (NRS; DV_1) and Pain Interference (PROMIS Pain Interference subscale; DV_2), were outcome variables. **CI_{bca}** (LL) = lower limit of a 95% confidence interval; **CI_{bca}** (UL) = upper limit. Analyses included child age and anxiety symptoms (pain interference model) and child race (pain intensity model) as covariates.